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FOR THE

Promotion of Engineering Education

PROCEEDINGS

OF THE

FOURTEENTH ANNUAL MEETING

HELD IN

ITHACA, N. Y., JULY 2 AND 3, 1906

Volume XIV

EDITED BY

DUGALD C. JACKSON CHARLES L. CRANDALL WM. T. MAGRUDER
Committee

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1906-1907

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Adams, Comfort A., Jr. Cambridge, Mass.	Professor of Electrical Engineering, Harvard University	1894
Alderson, Victor C. Golden, Colo.	President, Colorado School of Mines	1900
Aldrich, William S. Potsdam, N. Y.	Director, Clarkson School of Technology	1893
Allen, C. Frank Boston, Mass.	Professor of Railroad Engineering, Massachusetts Institute of Technology	1893
Allen, Charles M. 8 Dean St., Worcester, Mass.	Assistant Professor of Experimental Engineering, Worcester Polytechnic Institute	1903
Anderson, F. Paul Lexington, Ky.	Dean of the School of Mechanical and Electrical Engineering, Professor of Mechanical Engineering, State College of Kentucky	1894
Anderson, Douglas S. New Orleans, La.	Associate Professor of Electrical Engineering, Tulane University	1900
Anthony, Gardner C. Tufts College, Mass.	Professor of Technical Drawing and Dean of the Department of Engineering, Tufts College	1896
Arnold, Bion J. Chicago, Ill.	Consulting Electrical Engineer, 1539 Marquette Building	1896
Atkinson, Fred W. 55 Pineapple St., Brooklyn, N. Y.	President of the Polytechnic Institute of Brooklyn	1905
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Name and Address.	Title.	Date of Membership.
Ayer, Arthur W. 3403 Gray's Ferry Road, Philadelphia, Pa.	General Superintendent, Harrison Bros. & Co., Inc.	1894
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Barrows, Harold K. 6 Beacon St., Boston, Mass.	Hydraulic and Sanitary Engineer	1902
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Brooke, William E. Minneapolis, Minn.	Assistant Professor of Engineering Mathematics, University of Minnesota	1902
Brooks, J. Ansel Providence, R. I.	Assistant Professor of Mechanical Drawing, Brown University	1904

Name and Address.	Title.	Date of Membership.
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Brooks, Morgan Urbana, Ill.	Professor of Electrical Engineering, University of Illinois	1899
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Burton, Alfred E. Boston, Mass.	Dean, Massachusetts Institute of Technology	1904
Cajori, Florian 1119 Wood Ave., Colorado Springs, Colo.	Professor of Mathematics and Dean of School of Engineering, Colorado College	1904

Name and Address.	Title.	Date of Membership.
Caldwell, Edward........ 114 Liberty St., New York, N. Y.	Manager Book Department, McGraw Publishing Co., New York City.....	1905
Caldwell, Francis C. .... Columbus, Ohio.	Professor of Electrical Engineering, Ohio State University.............	1897
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Clark, John J. .... 919 Sunset St., Scranton, Pa.	Dean of the Faculty, International Correspondence Schools	1906
Colby, Irving A. .... 119 Stewart Ave., Ithaca, N. Y.	Instructor in Machine Design, Cornell University	1902

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Constant, Frank H. Minneapolis, Minn.	Professor of Structural Engineering, University of Minnesota	1896
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Copeland, Durward Houghton, Mich.	Instructor in Metallurgy, Michigan College of Mines	1905
Corthell, Elmer L. 1 Nassau, St., New York, N. Y.	Civil Engineer	1895
Coulter, Stanley 302 Perrin Ave., Lafayette, Ind.	Professor of Biology and Director of Biological Laboratory, Purdue University	1904
Cox, Nelson H. Lake City, Fla.	Assistant Professor of Civil and Mechanical Engineering, University of the State of Florida	1903
Crandall, Charles L. Ithaca, N. Y.	Professor of Railroad Engineering and Geodesy, Cornell University	1893
Creighton, William H. New Orleans, La.	Professor of Mechanical Engineering, Tulane University	1893
Crenshaw, Bolling H. Auburn, Ala.	Professor of Mathematics, Alabama Polytechnic Institute	1894
Dates, Henry B. Cleveland, Ohio.	Professor of Electrical Engineering, Case School of Applied Science	1904
Davis, Ellery W. Lincoln, Neb.	Dean of College of Literature, Science and the Arts and Professor of Mathematics, University of Nebraska	1902
Defoe, Luther M. Columbia, Mo.	Professor of Mechanics, University of Missouri	1904
Denison, Charles S. Ann Arbor, Mich.	Professor of Stereotomy, Mechanism and Drawing, University of Michigan	1893
Denton, James E. Hoboken, N. J.	Professor of Engineering Practice, Stevens Institute of Technology	1893
Denton, Frederick W. Houghton, Mich.	Superintendent Baltic and Trimountain Mines	1894
Derleth, Charles, Jr. Berkeley, Cal.	Associate Professor of Structural Engineering, University of California	1904

Name and Address.	Title.	Date of Membership.
Diemer, Hugo 2448 Park Ave.; Indianapolis, Ind.	Consulting Mechanical Engineer	1902
Diller, Harry E. 407 Wisconsin Ave., Oak Park, Ill.	In charge of Hawthorne Engineering Laboratories, Western Electric Company, Chicago, Ill.	1905
Doherty, Henry L. 40 Wall St., New York, N. Y.	Consulting Engineer	1904
Drane, Walter H. University, Miss.	Professor of Civil Engineering, University of Mississippi	1893
Drinker, Henry S. South Bethlehem, Pa.	President, Lehigh University	1905
Du Bois, A. Jay New Haven, Conn.	Professor of Civil Engineering, Yale University	1894
Dudley, Charles B. Altoona, Pa.	Chemist, Pennsylvania Railroad Company	1894
Dufour, Frank O. Urbana, Ill.	Assistant Professor of Structural Engineering, University of Illinois	1906
Duncan, Lindsay Denver, Colo.	Bridge Department, D. & R. G. R. R.	1901
Duncan, Louis 56 Pine St., New York, N. Y.	Consulting Electrical Engineer	1904
Duncan, Murray M. Ishpeming, Mich.	Agent Cleveland Cliffs Iron Co. and Member Board of Control Michigan College of Mines	1905
Durand, William F. Stanford University, California.	Professor of Marine Engineering, Leland Stanford Junior University	1899
Eddy, Henry T. Minneapolis, Minn.	Professor of Engineering and Mechanics, University of Minnesota	1893
Eddy, Horace T. Cincinnati, Ohio.	Professor of Electrical Engineering, University of Cincinnati	1903
Edmands, Samuel S. Brooklyn, N. Y.	Instructor in Applied Electricity, Pratt Institute	1903

Name and Address.	Title.	Date of Membership.
Emch, Arnold Solothurn, Switzerland.	Professor of Mathematics in the Kantonsschule	1904
Emory, Frederick L. Morgantown, W. Va.	Professor of Mechanics and Applied Mathematics, West Virginia University	1894
Engler, Edmund A. Worcester, Mass.	President, Worcester Polytechnic Institute	1897
Esterline, J. Walter 401 State St., West Lafayette, Ind.	Assistant Professor of Electrical Engineering, Purdue University	1903
Esty, William South Bethlehem, Pa.	Professor of Electrical Engineering, Lehigh University	1898
Evans, Herbert S. Boulder, Colo.	Professor of Electrical Engineering, University ot Colorado	1905
Faig, John T. 254 Greendale Ave., Clifton, Cincinnati, Ohio.	Professor of Mechanical Engineering, University of Cincinnati	1899
Farwell, Elmer S. 309 Broadway, New York, N. Y.	Consulting Engineer	1895
Fermier, Emilie J. College Station, Texas.	Professor of Mechanical Engineering, Texas Agricultural and Mechanical College	1903
Fernald, Robert H. St. Louis, Mo.	Professor of Mechanical Engineering, Washington University	1899
Fish, Fred A. Ames, Iowa.	Associate Professor of Electrical Engineering, Iowa State College	1905
Fisher, James, Jr. Houghton, Mich.	Professor of Mathematics and Physics, Michigan College of Mines	1899
Flather, John J. Minneapolis, Minn.	Professor of Mechanical Engineering, University of Minnesota	1893
Fletcher, Robert Hanover, N. H.	Professor of Civil Engineering, Director of Thayer School of Civil Engineering, Dartmouth College	1894
Flint, Walter Port Deposit, Md.	Supervising Engineer, The Jacob Tome Institute	1898

Name and Address.	Title.	Date of Membership.
Ford, Arthur H. Iowa City, Iowa.	Professor of Electrical Engineering, University of Iowa	1903
Foss, Fred E. State College, Pa.	Professor of Civil Engineering, Pennsylvania State College	1893
Fowler, Charles E. 737 New York Block, Seattle, Wash.	President of International Contract Co. and Lecturer University of Washington	1903
Foyé, Andrew E. 21 Park Row, New York, N. Y.	Secretary and Treasurer, Ryan-Parker Construction Company	1903
Frankforter, George B. Minneapolis, Minn.	Professor of Chemistry, University of Minnesota	1897
Franklin, William S. Bethlehem, Pa.	Professor of Physics, Lehigh University	1900
Freeman, William H. Burlington, Vt.	Professor of Electrical Engineering, University of Vermont	1902
Freeman, Clarence E. Chicago, Ill.	Director of Electrical Engineering Department, Armour Institute of Technology	1904
French, Arthur W. Worcester, Mass.	Professor of Civil Engineering, Worcester Polytechnic Institute	1900
French, Thomas E. Columbus, Ohio.	Professor of Engineering Drawing, Ohio State University	1899
Frink, Fred G. Urbana, Ill.	Assistant Professor of Civil Engineering, University of Illinois	1902
Fullan, M. Thomas J. Auburn, Ala.	Assistant in Mechanical Engineering, Alabama Polytechnic Institute	1897
Fuller, Almon H. University Station, Seattle, Wash.	Professor of Civil Engineering, University of Washington	1901
Galbraith, John Toronto, Ont.	Principal and Professor of Engineering, School of Practical Science	1893
Ganz, Albert F. Hoboken, N. J.	Professor of Electrical Engineering, Stevens Institute of Technology	1903
Giesecke, F. E. Berliner Strasse 46, Charlottenburg, Germany.	Professor of Drawing, Texas Agricultural and Mechanical College	1893

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GILL, JAMES H. Urbana, Ill.	Assistant Professor of Machine Construction, University of Illinois	1896
GILLETTE, HALBERT P. 1120–1121 Park Row Bldg., New York, N. Y.	Consulting Engineer	1905
GLADSON, WILLIAM N. Fayetteville, Ark.	Professor of Electrical Engineering, University of Arkansas	1903
GOETZE, FREDERICK A. New York, N. Y.	Dean of the Faculty of Applied Science, Columbia University	1906
GOODENOUGH, GEORGE A. Urbana, Ill.	Assistant Professor of Mechanical Engineering, University of Illinois	1900
GOSS, WILLIAM F. M. Lafayette, Ind.	Professor of Experimental Engineering and Dean of Schools of Engineering, Purdue University	1893
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GROAT, BENJAMIN F. Minneapolis, Minn.	Assistant Professor of Mathematics and Mechanics, School of Mines, University of Minnesota	1899
GROVER, NATHAN C. 81 North 18th St., East Orange, N. J.	Assistant Hydraulic Engineer, J. G. White & Co., 43 Exchange Place, New York, N. Y.	1894
HALSTED, GEORGE B. Boulder, Colo.	Professor of Mathematics, Colorado State Normal School	1899
HAMERSCHLAG, ARTHUR A. Pittsburg, Pa.	Director, Carnegie Technical Schools	1903

Name and Address.	Title.	Date of Membership.
Hancock, Edward L. Lafayette, Ind.	Assistant Professor of Applied Mechanics, Purdue University	1903
Haney, James P. 1233 Third Ave., New York, N. Y.	Director of Manual Training, New York City	1904
Harrington, John Lyle 608 New Nelson Bldg., Kansas City, Mo.	Consulting Engineer, Waddell & Harrington	1903
Harris, Abram W. Port Deposit, Md.	Director of The Jacob Tome Institute.	1897
Harris, Elmo G. Rolla, Mo.	Professor of Civil Engineering, School of Mines and Metallurgy, University of Missouri	1894
Hatt, William K. Lafayette, Ind.	Professor of Civil Engineering, Purdue University	1895
Haviland, Edwin, Jr. Potsdam, N. Y.	Professor of Mathematics and Civil Engineering, Clarkson School of Technology	1902
Hawes, Joseph H. 40 Fairmont St., Dorchester, Mass.	Teacher of Manual Training and Mechanical Drawing, Dorchester High School, Boston	1900
Hayford, John F. Washington, D. C.	Inspector of Geodetic Work and Chief of Computing Division, Coast and Geodetic Survey	1905
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Hayward, Harrison W. Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
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HIBBARD, H. WADE. Ithaca, N. Y.	Professor of Mechanical Engineering of Railways, Sibley College, Cornell University	1896
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HOAG, WILLIAM R. Minneapolis, Minn.	Professor of Civil Engineering, University of Minnesota	1893
HOFMAN, HEINRICH O. Boston, Mass.	Professor of Metallurgy, Massachusetts Institute of Technology	1894
HOLDEN, CHARLES A. Hanover, N. H.	Associate Professor of Civil Engineering, Thayer School of Civil Engineering, Assistant Professor of Mathematics, Dartmouth College	1901
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HOOD, OZNI P. Houghton, Mich.	Professor of Mechanical and Electrical Engineering, Michigan College of Mines	1893
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HOWE, CHARLES S. Cleveland, Ohio.	President of Case School of Applied Science	1902
HOWE, MALVERD A. Terre Haute, Ind.	Professor of Civil Engineering, Rose Polytechnic Institute	1894
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NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
HUMPHREYS, ALEXANDER C. Hoboken, N. J.	President of Stevens Institute of Technology	1903
HUMPHREYS, DAVID C. Lexington, Va.	Dean of the School of Engineering and Professor of Civil Engineering, Washington and Lee University	1893
HUNTER, JOHN A. Boulder, Colo.	Professor of Mechanical Engineering, University of Colorado	1904
HUNTINGTON, EDWARD V. 35 Fairfax Hall, Cambridge, Mass.	Assistant Professor of Mathematics, Harvard University	1906
HUTTON, FREDERICK R. New York, N. Y.	Professor of Mechanical Engineering, Columbia University	1894
HYDE, A. LINCOLN University Club, Columbia, Mo.	Assistant Professor of Bridge Engineering, University of Missouri	1904
IVES, HOWARD C. Worcester, Mass.	Assistant Professor of Railroad Engineering, Worcester Polytechnic Institute	1901
JACKSON, DUGALD C. Boston, Mass.	Professor of Electrical Engineering, Massachusetts Institute of Technology	1893
JACKSON, JOHN P. State College, Pa.	Professor of Electrical Engineering, Pennsylvania State College	1894
JACOBUS, D. S. New York, N. Y.	Babcock & Wilcox Company	1893
JACOBY, HENRY S. Ithaca, N. Y.	Professor of Bridge Engineering, Cornell University	1894
JAMES, WALTER H. Boston, Mass.	Instructor in Mechanical Engineering, Massachusetts Institute of Technology	1904
JAMESON, JOSEPH M. Brooklyn, N. Y.	Head of Department of Physics, Pratt Institute	1903
JENKINS, DAVID RHYS 815 Spruce St., Boulder, Colo.	Instructor in Electrical Engineering, University of Colorado	1906
JENSON, JOSEPH Logan, Utah.	Professor of Mechanical Engineering, State Agricultural College of Utah	1903
JETT, CARTER C. Jett, Ky.		1902

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
JOHNSON, LEWIS J. Cambridge, Mass.	Assistant Professor of Civil Engineering, Lawrence Scientific School, Harvard University	1898
JONES, BASSETT, JR. 1 Madison Ave., New York, N. Y.	Consulting Engineer	1904
JONES, CLEMENT R. Morgantown, W. Va.	Professor of Mechanical Engineering, West Virginia University	1895
JONES, FORREST R. 315 W. 96 St., New York, N. Y.	Professor of Manhattan Automobile School	1893
JONES, FREDERICK S. Minneapolis, Minn.	Professor of Physics and Dean of College of Engineering, University of Minnesota	1903
KAUP, WILLIAM J. Brooklyn, N. Y.	Instructor in Machine Construction, Pratt Institute	1903
KAVANAUGH, WILLIAM H. Minneapolis, Minn.	Professor of Experimental Engineering, University of Minnesota	1902
KAY, EDGAR B. University, Ala.	Professor of Civil Engineering, University of Alabama	1898
KELLY, WILLIAM Vulcan, Mich.	Agent Penn Iron Mining Company and Chairman Board of Control Michigan College of Mines	1905
KENERSON, WILLIAM H. 100 Morris Ave., Providence, R. I.	Associate Professor of Mechanical Engineering, Brown University	1903
KENNEDY, FRANK LOWELL 43 Appleton St., Cambridge, Mass.	Assistant Professor of Drawing and Machine Design, Lawrence Scientific School, Harvard University	1904
KENT, JAMES M. Kansas City, Mo.	Instructor in Steam and Electricity, Manual Training High School of Kansas City	1903
KENT, WILLIAM Syracuse, N. Y.	Dean of the College of Applied Science, Syracuse University	1894
KERR, CHARLES V. Wellsville, N. Y.	Chief Engineer, Kerr Turbine Co.	1902
KETCHUM, MILO S. Boulder, Colo.	Dean of the College of Engineering and Professor of Civil Engineering, University of Colorado	1903

Name and Address.	Title.	Date of Membership.
King, Roy S. 110 W. Norwich Ave., Columbus, Ohio.	Assistant Professor of Experimental Engineering, Ohio State University	1904
Kingsbury, Albert East Pittsburg, Pa.	Mechanical Engineer with Westinghouse Electrical and Manufacturing Company	1893
Kinsley, Carl Quadrangle Club, Chicago, Ill.	Assistant Professor of Physics, University of Chicago	1903
Knoch, Julius J. Fayetteville, Ark.	Professor of Civil Engineering, University of Arkansas	1898
Koch, Ernest H., Jr. 421 Park Place, Brooklyn, N. Y.	Instructor in Pratt Institute	1904
Kyser, Henry H. Clemson College, S. C.	Assistant Professor of Electrical Engineering, Clemson Agricultural College	1897
Ladd, George E. Rolla, Mo.	Director and Professor of Geology and Mining, School of Mines and Metallurgy	1901
Lambert, Preston A. South Bethlehem, Pa.	Assistant Professor of Mathematics, Lehigh University	1897
Landreth, Olin H. Schenectady, N. Y.	Professor of Civil Engineering, Union University	1893
Lane, Henry M. 610 Schofield Building, Cleveland, Ohio.	Secretary, The Foundry Supply Association	1900
Langsdorf, Alexander S. St. Louis, Mo.	Professor of Electrical Engineering, Washington University	1903
Lanza, Gaetano Boston, Mass.	Professor of Applied Mechanics, in charge of the Department of Mechanical Engineering, Massachusetts Institute of Technology	1893
Lawrence, C. Herbert West Raleigh, N. C.	Instructor in Mechanics and Machine Design, North Carolina College of Agriculture and Mechanic Arts	1906
Lawrence, James W. Fort Collins, Colo.	Professor of Mechanical Engineering, State Agricultural College	1898
Leutwiler, Oscar Adolph. 511 West Green St., Urbana, Ill.	Assistant Professor of Machine Design, University of Illinois	1906

Name and Address.	Title.	Date of Membership.
Lindemann, Charles A. Lewisburg, Pa.	Assistant Professor of Applied Mathematics, Bucknell University	1905
Linville, Clarence P. Box 362, State College, Pa.	Instructor in Metallurgy, Pennsylvania State College	1904
Longyear, John M. Marquette, Mich.	Member Board of Control, Michigan College of Mines	1904
Love, Andrew C. Houston, Tex., Care of S. P. Ry.		1900
Lucke, Charles Edward New York, N. Y.	Adjunct Professor of Mechanical Engineering, Columbia University	1906
Ludy, Llewellyn V. 229 University St., West Lafayette, Ind.	Professor of Mechanical Engineering, Purdue University	1903
Lund, Robert L. Little Rock, Ark.	Consulting Engineer	1902
McCaustland, Elmer J. Ithaca, N. Y.	Assistant Professor of Mining and Surveying, Cornell University	1902
McKibben, Frank P. Boston, Mass.	Assistant Professor of Civil Engineering, Massachusetts Institute of Technology	1904
McNair, Fred W. Houghton, Mich.	President, Michigan College of Mines.	1897
MacNaughton, James Calumet, Mich.	General Manager Calumet and Hecla Mines and Member Board of Control Michigan College of Mines	1905
Mack, John G. D. 222 Jefferson St., Madison, Wis.	Professor of Machine Design, College of Engineering, University of Wisconsin	1901
Macomber, George S. Ithaca, N. Y.	Assistant Professor of Electrical Engineering, Sibley College, Cornell University	1904
Macomber, Irwin J. 10 Bridge St., New York, N. Y.	Westinghouse, Church, Kerr & Co.	1902
Magowan, Charles S. Iowa City, Iowa.	Professor of Municipal and Sanitary Engineering, State University of Iowa	1896

Name and Address.	Title.	Date of Membership.
Magruder, William T. Columbus, Ohio.	Professor of Mechanical Engineering, Ohio State University	1893
Maitland, Alexander, Jr. Kansas City, Mo.	President of Kansas City Bridge Co.	1903
Mann, John L. Belle Fourche, Mont.	Assistant Engineer, Reclamation Service, U. S. Geol. Survey	1902
Marburg, Edgar Philadelphia, Pa.	Professor of Civil Engineering, University of Pennsylvania	1894
Marston, Anson Ames, Iowa.	Professor of Civil Engineering, Iowa State College	1894
Marvin, Frank O. Lawrence, Kan.	Dean of the School of Engineering and Professor of Civil Engineering, University of Kansas	1893
Marx, Charles D. Stanford University, Cal.	Professor of Civil Engineering, Leland Stanford Junior University	1893
Mathews, Hubert B. Brookings, S. Dak.	Professor of Physics and Electrical Engineering, South Dakota Agricultural College	1896
Matthews, Charles P. Lafayette, Ind.	Professor of Electrical Engineering, Purdue University	1898
Maurer, Edward R. Madison, Wis.	Professor of Mechanics, University of Wisconsin	1897
Mead, Elwood Washington, D. C.	Professor of the Institutions and Practice of Irrigation, University of California; Chief of Irrigation and Drainage Investigations of the U. S. Department of Agriculture	1901
Meeker, Warren H. Ames, Iowa.	Associate Professor of Mechanical Engineering, Iowa State College	1903
Mees, Carl L. Terre Haute, Ind.	President, Rose Polytechnic Institute.	1894
Mendenhall, Thomas C. Worcester, Mass.		1895
Merriman, Mansfield South Bethlehem, Pa.	Professor of Civil Engineering, Lehigh University	1893
Miggett, William L. 331 Jefferson St., Ann Arbor, Mich.	Superintendent of the Engineering Shops, University of Michigan	1902
Millar, Adam V. Madison, Wis.	Instructor in Mechanical Drawing and Descriptive Geometry, University of Wisconsin	1904

Name and Address.	Title.	Date of Membership.
Mitcham, George Nathan. Auburn, Ala.	Professor of Geology and Mining Engineering, Alabama Polytechnic Institute	1906
Monin, Louis C. Chicago, Ill.	Dean of Culture Studies and Professor of Economics and Philosophy, Armour Institute of Technology	1904
Moore, Herbert F. Madison, Wis.	Assistant Professor of Mechanics, University of Wisconsin	1905
Moore, Stanley H. St. Louis, Mo.	Director, Manual Training Department, McKinley High School	1902
Moran, Daniel E. 35 Nassau St., New York, N. Y.	Secretary and Engineer of Foundation and Contracting Co., New York City	1903
More, Charles C. University Station, Seattle, Wash.	Assistant Professor of Civil Engineering, University of Washington	1901
Morley, Frederick Lapeer, Mich.	Res. Engr. St. Clair Flats Survey for the State of Michigan	1896
Moyer, James A. Cambridge, Mass.	Instructor in Descriptive Geometry, Lawrence Scientific School, Harvard University	1904
Munroe, Henry S. New York, N. Y.	Professor of Mining, Columbia University	1893
Munroe, James P. 79 Summer St., Boston, Mass.	Treasurer, Munroe Felt and Paper Co., Member of Corporation of Massachusetts Institute of Technology	1904
Nagle, James C. College Station, Tex.	Professor of Civil Engineering, Agricultural and Mechanical College of Texas	1897
Neff, Frank H. Cleveland, Ohio.	Professor of Civil Engineering, Case School of Applied Science	1895
Nesbit, Arthur F. Durham, N. H.	Associate Professor of Physics and Electrical Engineering, New Hampshire College of Agriculture and Mechanic Arts	1902
Norris, Henry H. Ithaca, N. Y.	Professor of Electrical Engineering, Cornell University	1900
O'Byrne, J. F. Dahlonega, Ga.	Professor of Mining and Electrical Engineering, N. G. A. College	1905

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
OHLE, ERNEST L. Iowa City, Ia.	Professor of Steam Engineering and Head of the Department of Mechanical Engineering, State University of Iowa	1905
ORTON, EDWARD, JR. Columbus, Ohio.	Director of the Department of Clay Working and Ceramics, Ohio State University	1900
OSTRANDER, JOHN E. Amherst, Mass.	Professor of Mathematics and Civil Engineering, Massachusetts Agricultural College	1894
OWENS, ROBERT B. Montreal, Quebec.	Professor of Electrical Engineering, McGill University	1894
PALMER, THOMAS W. University, Ala.	Professor of Mathematics, University of Alabama	1905
PALMER, WALTER K. 718 Dwight Bldg., Kansas City, Mo.	Consulting Mechanical and Electrical Engineer	1899
PARK, CHARLES F. 62 Summer St., Taunton, Mass.	Assistant Professor of Mechanical Engineering, Massachusetts Institute of Technology	1903
PARSONS, FLOYD W. 505 Pearl St., New York, N. Y.	Associate Editor, Engineering and Mining Journal	1905
PENCE, WILLIAM D. Madison, Wis.	Professor of Railway Engineering, University of Wisconsin	1895
PETTEE, CHARLES H. Durham, N. H.	Professor of Mathematics, New Hampshire College	1898
PHETTEPLACE, THURSTON M. 1612 Broad St., Providence, R. I.	Instructor in Mechanical Engineering, Brown University	1903
PHILLIPS, JAMES D. Madison, Wis.	Assistant Professor of Engineering Drawing, University of Wisconsin	1899
PIERCE, CHARLES HENRY 606 Lincoln Ave., Urbana, Ill.	Instructor in Theoretical and Applied Mechanics, University of Illinois	1906
PORTER, DWIGHT Boston, Mass.	Professor of Hydraulic Engineering, Massachusetts Institute of Technology	1893

Name and Address.	Title.	Date of Membership.
Porter, John B. Montreal, Quebec.	Professor of Mining Engineering, McGill University	1904
Porter, J. Madison Easton, Pa.	Professor of Civil Engineering, Lafayette College	1893
Powell, Emery H. 1538 Madison Ave., Scranton, Pa.	Engineering Text-book Writer, International Correspondence School	1903
Price, Melvin Cincinnati, Ohio.	Professor of Mechanical Engineering, University of Cincinnati	1900
Pritchett, Henry S. New York, N. Y.	President, Carnegie Foundation for the Advancement of Teaching	1904
Puffer, William L. Boston, Mass.	Consulting Engineer	1903
Pupin, Michael I. New York, N. Y.	Professor of Electro-mechanics, Columbia University	1895
Puryear, Charles College Station, Tex.	Professor of Mathematics, Agricultural and Mechanical College of Texas	1901
Randall, Otis E. Providence, R. I.	Professor of Mechanical Drawing, Brown University	1903
Randolph, Lingan S. Blacksburg, Va.	Professor of Mechanical Engineering, Virginia Polytechnic Institute	1894
Ransom, James H. 119 Columbia St., West Lafayette, Ind.	Associate Professor of Chemistry, Purdue University	1904
Ray, Franklin A. 137 King Ave., Columbus, Ohio.	Professor of Mine Engineering, Dean of the College of Engineering, Ohio State University	1906
Raymond, Howard M. Chicago, Ill.	Dean of Engineering Studies and Professor of Experimental Physics, Armour Institute of Technology	1904
Raymond, William G. Iowa City, Iowa.	Dean of College of Applied Science and Professor of Civil Engineering, University of Iowa	1893
Reber, Louis E. State College, Pa.	Dean of School of Engineering, Professor of Mechanical Engineering, Pennsylvania State College	1893

Name and Address.	Title.	Date of Membership.
Reynolds, Herman W. Berkeley, Cal.	Assistant Professor of Mechanical Engineering, University of California..	1903
Richards, Charles R. Lincoln, Neb.	Professor of Mechanical Engineering and Director of the School of Mechanic Arts, University of Nebraska.	1895
Richards, Chas. Russell. New York, N. Y.	Director of Manual Training, Teachers College, Columbia University....	1904
Richards, Robert H. Boston, Mass.	Professor of Mining Engineering and Metallurgy, Massachusetts Institute of Technology	1895
Richardson, James P. 3918 Wyandotte St., Kansas City, Mo.	Prosso School	1903
Richter, Arthur W. Madison, Wis.	Professor of Experimental Engineering, University of Wisconsin	1894
Ricker, N. Clifford Urbana, Ill.	Professor of Architecture, University of Illinois	1894
Riggs, Walter M. Clemson College, S. C.	Professor of Electrical Engineering, and Director of the Department of Mechanical and Electrical Engineering, Clemson A. and M. College, South Carolina	1897
Rittenhouse, Leon H. Haverford, Pa.	Instructor in Engineering, Haverford College	1906
Robbins, Arthur G. Boston, Mass.	Assistant Professor of Highway Engineering, Massachusetts Institute of Technology	1894
Roberts, William J. Pullman, Wash.	Associate Professor of Mathematics and Civil Engineering, Washington Agricultural College and School of Science	1903
Robinson, Edward Burlington, Vt.	Professor of Mechanical Engineering, University of Vermont	1899
Robinson, Frederic H. Newark, Del.	Professor of Civil Engineering, Delaware College	1894
Robinson, Stillman W. 1353 Highland St., Columbus, Ohio.	Mechanical Engineer and Expert, Professor Emeritus of Mechanical Engineering, Ohio State University	1893

Name and Address.	Title.	Date of Membership.
Rodhouse, Thomas J. Columbia, Mo.	Instructor in Descriptive Geometry and Mechanical Drawing, University of Missouri	1904
Rondinella, Lino F. 728 Stephen Girard Bldg., Philadelphia, Pa.	Professor of Constructive Drawing, Central Manual Training School of Philadelphia	1903
Rosebrugh, Thomas R. Toronto, Ontario.	Associate Professor of Electrical Engineering, School of Practical Science.	1896
Rouillion, Louis, 20 West 44th St., New York, N. Y.	Adjunct Professor of Manual Training, Columbia University	1906
Rowe, George H. 1211 Fisher Building, Chicago, Ill.	Consulting Engineer	1906
Rowland, Arthur J. 4510 Osage Ave., Philadelphia, Pa.	Professor of Electrical Engineering, Drexel Institute	1903
Russell, Walter B. 749 Eastern Parkway, Brooklyn, N. Y.	Assistant Superintendent of Apprentices, N. Y. C. Lines	1903
Ryan, Harris J. Stanford University, Cal.	Professor of Electrical Engineering, Leland Stanford Junior University.	1901
Sanborn, Frank E. Columbus, Ohio.	Director, Industrial Arts Department, Secretary of the College of Engineering, Ohio State University	1899
Schneider, Herman Cincinnati, Ohio.	Professor of Civil Engineering, University of Cincinnati	1903
Schuerman, William H. Nashville, Tenn.	Dean of the Engineering Department, Professor of Civil Engineering, Vanderbilt University	1895
Scott, Arthur C. Austin, Tex.	Professor of Electrical Engineering, University of Texas	1903
Scott, Charles F. Pittsburg, Pa.	Consulting Engineer, Westinghouse Electric and Manufacturing Company	1904
Scrugham, James G. Monroe House, Reno, Nevada.	Professor of Mechanical Engineering, Nevada State University	1906

Name and Address.	Title.	Date of Membership
Sears, Thomas B. Sta. A, Lincoln, Neb.	Instructor in Civil Engineering, University of Nebraska	1906
Sedgwick, William T. Boston, Mass.	Professor of Biology, Massachusetts Institute of Technology	1896
Sever, George F. New York, N. Y.	Adjunct Professor of Electrical Engineering, Columbia University	1903
Shattuck, Harold Bemis State College, Pa.	Instructor in Civil Engineering, Pennsylvania State College	1906
Sheldon, Samuel Brooklyn, N. Y.	Professor of Physics and Electrical Engineering, Polytechnic Institute of Brooklyn	1903
Shepardson, George D. Minneapolis, Minn.	Professor of Electrical Engineering, University of Minnesota	1895
Shoop, Charles Franklin Minneapolis, Minn.	Instructor in Mechanical Engineering and Assistant in Mathematics, University of Minnesota	1906
Short, Robert L. Chicago, Ill.	Department of Mathematics, D. C. Heath & Co.	1902
Slichter, Charles S. Madison, Wis.	Professor of Applied Mathematics, University of Wisconsin	1906
Slocum, Roy H. Urbana, Ill.	Instructor in Municipal and Sanitary Engineering, University of Illinois	1903
Slocum, Stephen E. Cincinnati, Ohio.	Professor of Applied Mathematics, University of Cincinnati	1906
Smith, Albert W. 1101 East Madison Ave., Cleveland, Ohio.	Professor of Metallurgy, Case School of Applied Science	1904
Smith, Alton L. Worcester, Mass.	Assistant Professor of Drawing and Machine Design, Worcester Polytechnic Institute	1902
Smith, Earl B. Philadelphia, Pa.	Instructor in Charge of Mechanical Engineering Laboratories, Drexel Institute	1906
Smith, Harold B. Worcester, Mass.	Professor of Electrical Engineering, Worcester Polytechnic Institute	1898
Smith, Harry E. Brooklyn, N. Y.	Professor of Applied Mechanics, Pratt Institute	1895

Name and Address.	Title.	Date of Membership.
Smith, Herbert S. S. Princeton, N. J.	Professor of Applied Mechanics, Princeton University	1894
Smith, Leonard S. 938 University Ave., Madison, Wis.	Associate Professor of Topographic and Geodetic Engineering, University of Wisconsin	1903
Snow, Charles H. New York, N. Y.	Dean of School of Applied Science, New York University	1895
Snow, Walter B. 29 Russell Ave., Watertown, Mass.	Manager, Advance Department, B. F. Sturtevant Co., Hyde Park, Mass.	1899
Solberg, Halvor C. Brookings, S. D.	Professor of Mechanical Engineering, South Dakota Agricultural College	1894
Spalding, Frederick P. Columbia, Mo.	Professor of Civil Engineering, University of State of Missouri	1893
Spangler, Henry W. Philadelphia, Pa.	Professor of Mechanical Engineering, University of Pennsylvania	1895
Sperr, Frederick W. Houghton, Mich.	Professor of Civil and Mining Engineering, Michigan College of Mines	1896
Spinney, Louis B. Ames, Iowa.	Professor of Physics and Electrical Engineering, Iowa State College	1899
Spofford, Charles M. Brooklyn, N. Y.	Professor of Civil Engineering, Polytechnic Institute	1904
Springer, Frank W. Minneapolis, Minn.	Assistant Professor of Electrical Engineering, University of Minnesota	1896
Stanwood, James B. Cincinnati, Ohio.	Director, Technical School of Cincinnati	1894
Steel, Alvin A. Fayetteville, Ark.	Assistant Professor of Geology and Mining, University of Arkansas	1905
Stewart, Louis B. Toronto, Ontario.	Lecturer in Surveying, School of Practical Science	1897
Stone, Winthrop E. 146 North Grant St., Lafayette, Ind.	President, Purdue University	1904
Stout, Oscar V. P. Lincoln, Neb.	Professor of Civil Engineering, University of Nebraska	1894

Name and Address.	Title.	Date of Membership.
Stubbs, Joseph E. Reno, Nev.	President, Nevada State University	1897
Swain, George F. Boston, Mass.	Professor of Civil Engineering, Massachusetts Institute of Technology	1893
Swift, Walter Sheffield, England.	Secretary of Technical Department, University College	1902
Talbot, Arthur N. Urbana, Ill.	Professor of Municipal and Sanitary Engineering, University of Illinois	1893
Talbot, Henry P. Boston, Mass.	Professor of Analytical Chemistry, Massachusetts Institute of Technology	1903
Taylor, Thomas U. Austin, Tex.	Professor of Civil Engineering, University of Texas	1902
Taylor, William D. Chicago, Ill.	Chief Engineer, Chicago and Alton Railway Co.	1894
Thach, Charles C. Auburn, Ala.	President, Alabama Polytechnic Institute	1905
Thaler, Joseph A. Bozeman, Mont.	Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts	1901
Thomas, Charles W. West Raleigh, N. C.	Professor of Mechanical Engineering, The North Carolina College of Agriculture and Mechanic Arts	1904
Thomas, Robert G. Charleston, S. C.	Professor of Mathematics and Engineering, South Carolina Military Academy	1894
Thornburg, Charles L. South Bethlehem, Pa.	Professor of Mathematics and Astronomy, Lehigh University	1894
Timmerman, Arthur H. St. Louis, Mo.	Superintendent, Wagner Electric Mfg. Co.	1894
Titsworth, Alfred A. 590 George St., New Brunswick, N. J.	Professor of Civil Engineering and Graphics, Rutgers College	1895
Towle, William M. Enosburg Falls, Vt.		1895
Townsend, Edgar J. 510 John St., Champaign, Ill.	Professor of Mathematics, Dean of the College of Science, University of Illinois	190[illegible]

Name and Address.	Title.	Date of Membership.
Turneaure, Frederick E. . Madison, Wis.	Dean of College of Engineering, University of Wisconsin...........	1894
Turner, Daniel L. .... 220 W. 107th St., New York, N. Y.	General Inspector of Stations, Board of Rapid Transit Commissions, New York City........................	1898
Turner, William P. .... Lafayette, Ind.	Assistant Professor of Practical Mechanics, Purdue University.........	1900
Turrill, Sherman M. ..... 54 Church St., Bethlehem, Pa.	Civil Engineer	1903
Tyler, Harry W. .... 491 Boylston St., Boston, Mass .	Professor of Mathematics, Massachusetts Institute of Technology.......	1894
VanHise, Charles R. ..... Madison, Wis.	President, University of Wisconsin...	1904
Van Ornum, John L. ..... St. Louis, Mo.	Professor of Civil Engineering, Washington University............	1895
Vedder, Herman K. .... Agricultural College, Mich.	Professor of Mathematics and Civil Engineering, Michigan State Agricultural College..................	1894
Vosskuehler, Joseph H. .. Madison, Wis.	Assistant Professor of Machine Design, University of Wisconsin......	1902
Votey, J. William .... Burlington, Vt.	Professor of Civil Engineering and Dean of Engineering Department, University of Vermont............	1902
Waddell, J. A. L. .... Kansas City, Mo.	Consulting Bridge Engineer of Waddell and Harrington...............	1893
Wadsworth, Joel E. .... 22 Morsemere Place, Yonkers, N. Y.	Resident Engineer, American Bridge Co.	1895
Wadsworth, M. Edward .. State College, Pa.	Professor of Mining and Geology, Pennsylvania State College.........	1895
Waldo, Clarence A. .... Lafayette, Ind.	Head Professor of Mathematics, Purdue University................	1897
Walker, Elton D. .... State College, Pa.	Professor of Hydraulic and Sanitary Engineering, Pennsylvania State College	1895

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WALLACE, JACOB H. Boulder, Colo.	Instructor in Engineering Drawing, University of Colorado	1905
WALLACE, JOHN F. 355 Dearborn St., Chicago, Ill.	Consulting Engineer	1903
WATERBURY, LESLIE A. 907 California Ave., Urbana, Ill.	Instructor in Civil Engineering, University of Illinois	1906
WEBB, J. BURKETT Hoboken, N. J.	Professor of Mathematics and Mechanics, Stevens Institute of Technology	1906
WHIPPLE, GEORGE C. 220 Broadway, New York, N. Y.	Consulting Engineer and Sanitary Expert of Hazen and Whipple	1896
WHITE, JAMES M. Champaign, Ill.	Professor of Architectural Engineering and Dean of Engineering College, University of Illinois	1900
WHITNEY, WILLIS R. Schenectady, N. Y.	Director of Research Laboratory of the General Electric Company, Schenectady, N. Y.	1902
WILEY, WILLIAM O. 43 and 45 E. 19th St., New York, N. Y.	Publisher of Scientific Books, Secretary John Wiley and Sons	1904
WILLETT, JAMES R. 434 Jackson Boulevard, Chicago, Ill.	Architect	1896
WILLIAMS, FRANK B. Schenectady, N. Y.	Professor of Engineering Mathematics, Union University	1901
WILLIAMS, SYLVESTER N. Mt. Vernon, Iowa.	Professor of Civil Engineering, Cornell College	1893
WILLISTON, ARTHUR L. Brooklyn, N. Y.	Director, Department of Science and Technology, Pratt Institute	1897
WILMORE, JOHN J. Auburn, Ala.	Professor of Mechanical Engineering, Alabama Polytechnic Institute	1894
WOLCOTT, EDSON RAY Golden, Colo.	Professor of Physics, Colorado School of Mines	1906

NAME AND ADDRESS.	TITLE.	DATE OF MEMBERSHIP.
WOOD, ARTHUR J. State College, Pa.	Assistant Professor of Experimental Engineering, Pennsylvania State College	1898
WOODBRIDGE, SAMUEL H. Boston, Mass.	Associate Professor of Heating and Ventilation, Massachusetts Institute of Technology	1904
WOODWARD, CALVIN M. St. Louis, Mo.	Dean of the School of Engineering and Architecture, Washington University	1894
WOODWARD, ROBERT S. 1513 Sixteenth St., Washington, D. C.	President, Carnegie Institution, Washington, D. C.	1894
WRENTMORE, CLARENCE G. 933 Forest Ave., Ann Arbor, Mich.	Assistant Professor of Civil Engineering, University of Michigan	1904
YOUNG, LEWIS E. Golden, Colo.	Professor of Mining, Colorado School of Mines	1903
ZIMMERMAN, OLIVER B. Charles City, Iowa.	Mechanical Engineer and Chief Draftsman, Hart-Parr Co.	1902
ZIWET, ALEXANDER Ann Arbor, Mich.	Professor of Mathematics, University of Michigan	1897

GEOGRAPHICAL DISTRIBUTION OF MEMBERS.

Names in italics are those of persons not engaged in teaching.

Alabama.—Auburn; B. H. Crenshaw; M. T. J. Fullan; G. N. Mitcham; C. C. Thach; J. J. Wilmore. (5.) **University**; E. B. Kay; T. W. Palmer. (2.)

Arkansas.—Fayetteville; W. M. Gladson; J. J. Knoch; A. A. Steel. (3.) **Little Rock**; *R. L. Lund.* (1.)

California.—Berkeley; S. B. Christy; C. Derleth, Jr.; H. W. Reynolds. (3 + 1 = 4.) **Stanford University**; W. F. Durand; L. M. Hoskins; C. D. Marx; H. J. Ryan. (4.)

Colorada.—Boulder; (University.) H. S. Evans; J. A. Hunter; D. R. Jenkins; M. S. Ketchum; J. H. Wallace. (5.) (State Normal Sch.) G. B. Halsted. (1.) **Colorado Springs**; F. Cajori. (1.) **Denver**; *Lindsay Duncan.* (1.) **Golden**; V. C. Alderson; C. R. Burger; E. R. Wolcott; L. E. Young. (4.) **Ft. Collins**; L. S. Carpenter; J. W. Lawrence. (2.)

Connecticut.—New Haven; S. E. Barney, Jr.; A. J. DuBois. (2.)

Delaware.—Newark; F. H. Robinson. (1.)

District of Columbia.—Washington; (Univ. of Cal.) E. Mead. (1.) (Carnegie Institution.) R. S. Woodward. (1.) (City.) *B. R. Green; J. F. Hayford.* (2.)

Florida.—Lake City; N. H. Cox. (1.)

Georgia.—Dahlonega; J. F. O'Byrne. (1.)

Illinois.—Chicago; (Armour Inst.) R. Burnham; C. E. Freeman; L. C. Monin; R. M. Raymond. (4.) (University.) C. Kinsley. (1.) (City) *B. J. Arnold; O. Bates; W. H. Bixby; G. M. Brill; W. M. Camp; G. F. Horton; C. W. Hotchkiss; G. H. Rowe; R. L. Short; W. D. Taylor; J. F. Wallace; J. R. Willett.* (12.) **Oak Park**; *H. E. Diller.* (1.) **Champaign**; I. O. Baker; E. J. Townsend; J. M. White. (3.) **Urbana**; L. P. Breckenridge; M. Brooks; F. O. Dufour; F. G. Frink; J. H. Gill; G. A. Goodenough; O. A. Leutwiler; C. H. Pierce; N. C. Ricker; R. H. Slocum; A. N. Talbot; L. A. Waterbury. (12.)

Indiana.—Indianapolis; *H. Diemer.* (1.) **Lafayette**; S. Coulter; J. W. Esterline; W. F. M. Goss; E. L. Hancock; W. K. Hatt; L. V. Ludy; C. P. Matthews; J. H. Ransom; W. E. Stone; W. P. Turner; C. A. Waldo. (11.) **Terre Haute**; T. Gray; M. A. Howe; C. L. Mees. (3.)

Iowa.—Ames; S. W. Beyer; G. W. Bissell; F. A. Fish; A. Marston; W. H. Meeker; L. B. Spinney. (6.) **Charles City**; *O. B. Zimmer-*

man. (1.) **Iowa City**; A. H. Ford; F. G. Highbee; C. S. Magowan; E. L. Ohle; W. G. Raymond. (5.) **Mt. Vernon**; S. N. Williams. (1.)

Kansas.—Lawrence; F. O. Marvin. (1.)

Kentucky.—Jett; *C. C. Jett.* (1.) **Lexington**; F. P. Anderson; J. P. Brooks. (2.)

Louisiana.—Baton Rouge; A. M. Herget. (1.) **New Orleans**; D. S. Anderson; W. H. Creighton. (2.)

Maine.—Orono; H. S. Boardman. (1.)

Maryland.—Port Deposit; W. Flint; A. W. Harris. (2.)

Massachusetts.—Amherst; J. E. Ostrander. (1.) **Boston**; (Mass. Inst.) C. F. Allen; C. B. Breed; A. E. Burton; H. W. Hayward; H. O. Hofman; D. C. Jackson; W. H. James; G. Lanza; F. P. McKibben; D. Porter; R. H. Richards; A. G. Robbins; W. T. Sedgwick; G. F. Swain; H. P. Talbot; H. W. Tyler; S. H. Woodbridge. (17 + 3 = 20.) (City.) *H. K. Barrows; J. P. Munroe; W. L. Puffer.* (3.) **Cambridge**; C. A. Adams, Jr.; I. N. Hollis; E. V. Huntington; L. J. Johnson; F. L. Kennedy; J. A. Moyer. (6.) **Dorchester**; J. H. Hawes. (1.) **E. Bridgewater**; *C. A. Chandler.* (1.) **Jamaica Plain**; C. L. Adams. (M. I. T.) **Stoneham**; C. H. Chase. (M. I. T.) **Taunton**; C. F. Parks. (M. I. T.) **Tufts College**; G. C. Anthony; C. D. Bray. (2.) **Watertown**; *W. B. Snow.* (1.) **Worcester**; C. M. Allen; E. A. Engler; A. W. French; H. C. Ives; T. C. Mendenhall; A. L. Smith; H. B. Smith. (7.)

Michigan.—Agricultural College; H. K. Vedder. (1.) **Ann Arbor**; M. E. Cooley; C. S. Denison; W. L. Miggett; C. G. Wrentmore; A. Ziwet. (5.) **Calumet**; *J. MacNaughton.* (1.) **Houghton**; L. S. Austin; G. L. Christensen; D. Copeland; F. W. Denton; J. Fisher, Jr.; E. D. Grant; O. P. Hood; F. W. McNair; F. W. Sperr. (9.) **Ishpeming**; *M. M. Duncan.* (1.) **Lapeer**; *F. Morley.* (1.) **Marquette**; *J. M. Longyear.* (1.) **Vulcan**; *W. Kelly.* (1.)

Minnesota.—Minneapolis; F. H. Bass; W. E. Brooke; F. H. Constant; Henry T. Eddy; J. J. Flather; G. B. Frankforter; B. F. Groat; A. E. Haynes; W. R. Hoag; F. S. Jones; W. H. Kavanaugh; C. F. Shoop; G. D. Shepardson; F. W. Springer. (14.)

Mississippi.—University; H. L. Drane; A. Hume. (2.)

Missouri.—Columbia; L. M. Defoe; A. M. Greene, Jr.; A. L. Hyde; T. J. Rodhouse; F. P. Spalding. (5.) **Kansas City**; (High School.) J. M. Kent. (1.) (Prosso School.) J. P. Richardson. (1.) (City.) *J. L. Harrington; I. G. Hedrick; A. Maitland, Jr.; W. K. Palmer; J. A. L. Waddell.* (5.) **Rolla**; E. G. Harris; G. E. Ladd. (2.) **St. Louis**; (High School.) S. H. Moore. (1.) (Washington Univ.) R. H. Fernald; A. S. Langsdorf; J. L. Van

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Montana.—Bozeman; J. A. Thaler. (1.) **Helena**; *J. S. Baker.* (1.) **Belle Fourche**; *J. L. Mann.* (1.)

Nebraska.—Lincoln; G. R. Chatburn; E. W. Davis; C. R. Richards; T. B. Sears; O. V. P. Stout. (5.) **Culbertson**; *J. A. Green.* (1.)

Nevada.—Reno; J. G. Scrugham; J. E. Stubbs. (2.)

New Hampshire.—Durham; A. F. Nesbit; C. H. Pettee. (2.) **Hanover**; R. Fletcher; J. V. Hazen; C. A. Holden. (3.)

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North Carolina.—W. Raleigh; C. H. Lawrence; C. W. Thomas. (2.)

Ohio.—Cincinnati; Horace T. Eddy; J. T. Faig; M. Price; H. Schneider; S. E. Slocum; J. B. Stanwood. (6.) **Cleveland**; (Case School.) C. H. Benjamin; H. B. Dates; C. S. Howe; F. H. Neff; A. W. Smith. (5.) (City.) *H. W. Brown; H. M. Lane.* (2.) **Columbus**; J. N. Bradford; F. C. Caldwell; T. E. French; E. A. Hitchcock; R. S. King; W. T. Magruder; E. Orton, Jr.; F. A. Ray; S. W. Robinson; F. E. Sanborn. (10.)

Pennsylvania.—Allegheny; D. Carhart. (1.) **Altoona**; *C. B. Dudley.* (1.) **Bethlehem**; W. S. Franklin. (Lehigh.) (City.) *S. M. Turrill.* (1.) **Easton**; J. M. Porter. (1.) **E. Pittsburg**; *A. Kingsbury.* (1.) **Haverford**; L. H. Rittenhouse. (1.) **Lewisburg**;

C. A. Lindeman. (1.) **Philadelphia;** (Central M. T. School.) L. F. Rondinella. (1.) (Drexel Inst.) A. J. Rowland; E. B. Smith. (2.) (Univ. of Pa.) E. Marburg; H. W. Spangler. (2.) (City.) *A. W. Ayer; T. R. Beyer.* (2.) **Pittsburg;** (Carnegie Tech. Sch.) A. A. Hamerschlag. (1.) (City.) *C. F. Scott.* (1.) **Scranton;** J. J. Clark; E. H. Powell. (2.) **Sewickley;** J. R. Benton. (1.) **South Bethlehem;** H. S. Drinker; W. Esty; P. A. Lambert; M. Merriman; C. L. Thornburg. (5 + 1 = 6.) **State College;** F. E. Foss; J. P. Jackson; C. P. Linville; L. E. Reber; H. B. Shattuck; M. E. Wadsworth; E. D. Walker; A. J. Wood. (8.)

Rhode Island.—Providence; A. H. Blanchard; J. A. Brooks; J. E. Hill; W. H. Kenerson; C. M. Phetteplace; O. E. Randall. (6.)

South Carolina.—Charleston; R. G. Thomas. (1.) **Clemson College;** H. H. Kyser; W. M. Riggs. (2.)

South Dakota.—Brookings; H. B. Mathews; H. C. Solberg. (2.)

Tennessee.—Knoxville; B. Ayers; W. W. Carson. (2.) **Nashville;** W. H. Schuerman. (1.) **Sewanee;** S. M. Barton. (1.)

Texas.—Austin; H. Y. Benedict; A. C. Scott; T. U. Taylor. (3.) **College Station;** N. H. Brown; E. J. Fermier; F. E. Giesecke; J. C. Nagle; C. Puryear. (5.) **Houston;** *A. C. Love.* (1.)

Utah.—Logan; J. Jenson. (1.)

Vermont.—Burlington; W. H. Freeman; E. Robinson; J. W. Votey. (3.) **Enos Falls;** *W. M. Towle.* (1.)

Virginia.—Blacksburg; L. S. Randolph. (1.) **Lexington;** D. C. Humphreys. (1.)

Washington.—Pullman; W. J. Roberts. (1.) **Seattle;** C. E. Fowler; A. H. Fuller; C. C. More. (3.)

West Virginia.—Morgantown; W. H. Boughton; F. L. Emory; C. R. Jones. (3.)

Wisconsin.—Beloit; *A. T. Bruegel.* (1.) **Madison;** M. C. Beebe; S. Bull; C. F. Burgess; J. G. D. Mack; E. R. Maurer; A. V. Millar; H. F. Moore; W. D. Pence; J. D. Phillips; A. W. Richter; C. S. Slichter; L. S. Smith; F. E. Turneaure; C. R. Van Hise; J. H. Voskuehler. (15.)

Australia.—Sydney, N. S. W.; S. H. Barraclough. (1.)

Canada.—Fredericton, New Brunswick; E. E. Brydone-Jack. (1.) **Montreal, Quebec;** H. T. Bovey; R. B. Owens; J. B. Porter. (3.) **Toronto, Ontario;** J. Galbraith; T. R. Rosebrugh; L. B. Stewart. (3.)

England.—Sheffield; W. Swift. (1.)

Switzerland.—Solothurn; A. Emch. (1.)

GEOGRAPHICAL SUMMARY OF MEMBERS.

Alabama	7	Maryland	2	South Carolina	3
Arkansas	4	Massachusetts	42	South Dakota	2
California	8	Michigan	20	Tennessee	4
Colorado	14	Minnesota	14	Texas	9
Connecticut	2	Mississippi	2	Utah	1
Delaware	1	Missouri	20	Vermont	4
District of Columbia	3	Montana	3	Virginia	2
Florida	1	Nebraska	6	Washington	4
Georgia	1	Nevada	2	West Virginia	3
Illinois	33	New Hampshire	5	Wisconsin	16
Indiana	15	New Jersey	8	Australia	1
Iowa	13	New York	59	Canada	7
Kansas	1	North Carolina	2	England	1
Kentucky	3	Ohio	23	Switzerland	1
Louisiana	3	Pennsylvania	33		
Maine	1	Rhode Island	6	Total	415

INSTITUTIONS REPRESENTED.

	Members.	No.
Massachusetts Institute of Technology by	20	1.
University of Wisconsin	15	1.
University of Illinois	14	
University of Minnesota	14	2.
Purdue University	11	1.
Columbia University	10	
Ohio State University	10	2.
Cornell University	9	
Michigan College of Mines	9	2.
Pennsylvania State College	8	1.
Worcester Polytechnic Institute	7	1.
Brown University	6	
University of Cincinnati	6	
Harvard University	6	
Iowa State College	6	
Lehigh University	6	
Pratt Institute	6	6.
Alabama Polytechnic Institute	5	
Case School of Applied Science	5	
University of Colorado	5	
University of Iowa	5	
University of Michigan	5	

	Members.	No.
University of Missouri	5	
University of Nebraska	5	
Agricultural and Mechanical College of Texas	5	8.
Armour Institute	4	
University of California	4	
Colorado School of Mines	4	
Leland Stanford Junior University	4	
Stevens Institute of Technology	4	
Washington University	4	6.
University of Arkansas	3	
Polytechnic Institute of Brooklyn	3	
Clarkson School of Technology	3	
McGill University	3	
Rose Polytechnic Institute	3	
University of Texas	3	
Thayer School of Civil Engineering of Dartmouth College	3	
Toronto School of Applied Science	3	
University of Vermont	3	
University of Washington	3	
University of West Virginia	3	11.
University of Alabama	2	
Clemson College	2	
Colorado State Agricultural College	2	
Drexel Institute	2	
University of the State of Florida	2	
International Correspondence Schools	2	
Jacob Tome Institute	2	
State College of Kentucky	2	
University of Mississippi	2	
Missouri School of Mines and Metallurgy	2	
Nevada State University	2	
New Hampshire College of Agriculture and Mechanic Arts	2	
North Carolina College of Agriculture and Mechanic Arts	2	
University of Pennsylvania	2	
South Dakota Agricultural College	2	
University of Tennessee	2	
Tufts College	2	
Tulane University	2	
Union University	2	
Yale University	2	20.
Bucknell University	1	
Carnegie Foundation for the Advancement of Teaching	1	
Carnegie Institution	1	

	Members.	No.
Carnegie Technical School	1	
University of Chicago	1	
Colorado College	1	
Colorado State Normal School	1	
Cornell College	1	
Delaware College	1	
Dorchester High School	1	
Haverford College	1	
James Milliken University	1	
University of Kansas	1	
Kansas City High School	1	
Lafayette College	1	
Louisiana State University	1	
University of Maine	1	
Manhattan Automobile School	1	
Massachusetts Agricultural College	1	
Michigan Agricultural College	1	
Montana College of Agriculture and Mechanic Arts	1	
University of New Brunswick	1	
New York Public Schools	1	
New York University	1	
North Georgia Agricultural College	1	
Philadelphia Public Schools	1	
Princeton University	1	
Prosso School	1	
Rutgers College	1	
University College, Sheffield	1	
Kantonsschule, Solothurn	1	
St. Louis Public High Schools	1	
University of the South	1	
South Carolina Military Academy	1	
University of Sydney	1	
University of Syracuse	1	
State Agricultural College of Utah	1	
Vanderbilt University	1	
University of Virginia	1	
Washington Agricultural College	1	
Washington and Lee University	1	
Western University of Pennsylvania	1	42.

SUMMARY BY OCCUPATIONS.

	Teachers of.	Practitioners.
Architecture	3	1
Biology	2	
Chemistry	3	2
Civil Engineering	82	22
Drawing	16	
Electrical Engineering	38	9
Manual Training	8	
Mathematics	36	1
Mechanical Engineering	69	17
Mechanics	13	
Metallurgy	5	
Mining Engineering	14	7
Physics	13	
Shopwork	3	
Trade-school	1	
Unclassified	9	15
Deans only	7	
Presidents	20	
Total	342	73

GENERAL SUMMARY

Different Institutions represented:—	
Colleges and University teaching Engineering, Domestic	85
Foreign	6
Manual Training, High, Correspondence, and Trade Schools	13
Total Institutions	104
Teachers, and, in many cases, also practitioners	342
Practitioners, not teaching	73
Total Members	415

DECEASED MEMBERS.

Name.	Year of Election.	Date of Death.	Memoir. Vol.	Page.
George W. Atherton	1904	July 24, 1906.	XIV,	292
Volney G. Barbour	1894	June 4, 1901.	IX,	340
Charles B. Brush	1893	June 3, 1897.	VII,	181
Eckley B. Coxe	1894	May 13, 1895.	VII,	182
Thomas M. Drown	1895	Nov. 16, 1904.	XII,	244
Francis R. Fava, Jr.	1894	March 28, 1896.	VII,	183
Estevan A. Fuertes	1894	January 16, 1903.	XI,	372
Henry Fulton	1894	December 6, 1901.	X,	258
Herbert G. Geer	1894	March 7, 1900.	VIII,	371
Lyman Hall	1904	Aug. 16, 1905.	XIV,	287
Albert H. Heller	1903	Feb. 20, 1906.	XIV,	290
John B. Johnson	1893	June 23, 1902.	X,	259
Rodney G. Kimball	1894	April 25, 1900.	X,	261
Burton S. Lanphear	1897	October 14, 1904.	XII,	249
Benjamin F. La Rue	1899	Dec. 22, 1903.	XII,	243
Justus M. Silliman	1894	April 15, 1896.	VII,	184
James H. Stanwood	1894	May 24, 1896.	VII,	185
Robert H. Thurston	1893	October 25, 1903.	XII,	246
Alphonse N. Van Daell	1897	March 28, 1899.	VII,	186
John R. Wagner	1894	January 21, 1899.	VII,	187
Francis A. Walker	1896	January 5, 1897.	VII,	188
Howard S. Webb	1897	June 12, 1905.	XIV,	286
Nelson O. Whitney	1893	March 17, 1901.	IX,	339
De Volson Wood	1893	June 27, 1897.	V,	325

PAST OFFICERS.

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JOHN GALBRAITH, JOHN M. ORDWAY, 1896–7,
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C. FRANK ALLEN, HENRY W. SPANGLER, 1898–9,
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THOMAS GRAY, ALBERT KINGSBURY, 1900–1,
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JOHN J. FLATHER, FRED W. McNAIR, 1902–3,
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ALBERT KINGSBURY, 1897–9,
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CLARENCE A. WALDO, 1902–4,
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Members of Previous Councils.

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John Galbraith,
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Storm Bull,
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Terms of Office Expired in 1901.

T. M. Drown,*
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Brown Ayers,
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Terms of Office Expired in 1904.

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W. G. Raymond,
L. S. Randolph.
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L. E. Reber,

Terms of Office Expired in 1905.

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L. J. Johnson,
Elwood Mead,
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W. M. Towle,
J. L. Van Ornum,

Terms of Office Expired in 1906.

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Frederick P. Spalding,
Charles S. Howe,
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CONSTITUTION

OF THE

Society for the Promotion of Engineering Education

1. NAME.—This organization shall be called the SOCIETY FOR THE PROMOTION OF ENGINEERING EDUCATION.

2. MEMBERS.—Members of the Society shall be those who occupy, or have occupied, responsible positions in the work of engineering instruction, together with such other persons as may be recommended by the Council.

Honorary Members of the Society shall be such persons as may be recommended by unanimous vote of the Council after a letter ballot. In taking this ballot, the Secretary is directed to close the polls one month after the names of the candidates are sent out. Councilors not heard from will be counted in favor of the candidate. Honorary Members shall not have the right to vote, shall not be eligible to office, and shall not be required to pay any fees or dues.

Life Members of the Society shall be those members not in arrears who have paid Fifty Dollars into the Treasury of the Society at one time.

The name of each candidate for membership shall be proposed in writing to the Council by two members to whom he is personally known. Such name, if approved by the Council, shall be voted on by the Society at the annual meeting; or, during the period between Annual Meetings, the Secretary may at any time submit to the council the names of candidates with the names of their sponsors. An affirmative letter ballot of three-fourths of those whose vote reaches the Secretary within one month of the time of sending out the names of candidates will suffice to elect. Such elections shall be credited to the previous Annual Meeting, and dues will date from that time.

3. OFFICERS.—There shall be a President, two Vice-Presidents, a Secretary and a Treasurer, each to hold office for one year. They shall be chosen by vote of the members at the annual meeting.

4. COUNCIL.—The Council of this Society shall consist of twenty-one elective members, one-third of whom shall retire annually. The officers and the Past Presidents of the Society shall be members of the Council *ex officiis.*

Any member of this Society shall be eligible to election to the Council, provided that not more than one elective member shall be from any one college.

Members of the Council shall be elected by ballot by the Society, at its annual meeting.

The Council shall constitute a general executive body of the Society, pass on proposals for membership, elect candidates *ad interim,* attend to all business of the Society, receive and report on propositions for amendments to the constitution, and shall have power to fill temporary vacancies in the offices.

5. NOMINATING COMMITTEE.—The Nominating Committee shall consist of the Past Presidents and the seven elective members of the Council retiring the following year, provided, however, that if, of this committee, the number in attendance at any meeting be less than five, the President shall make appointments so as to form a committee of five.

6. FEES AND DUES.—The admission fee, which shall also include the first year's dues, shall be three dollars, and the annual dues thereafter three dollars, payable at the time of the annual meeting. Those in arrears more than one year shall not be entitled to vote, nor to receive copies of the Proceedings, and such members shall be notified thereof by the Secretary one month previous to the annual meeting. Any member who shall be in arrears more than two years and shall have been duly notified by the Secretary, shall be thereby dropped from the roll, excepting such arrearages shall be paid previous to the next ensuing annual meeting; and no such member shall be restored until he has paid his arrears.

7. MEETINGS.—There shall be a regular meeting occurring at

the time and place of the meeting of the American Association for the Advancement of Science, or of some one of the National Engineering Societies, or otherwise as the Council may determine.

8. PUBLICATIONS.—The Proceedings of the Society, and such papers or abstracts as may be approved by the Council, shall be published as soon as possible after each annual meeting.

9. AMENDMENTS.—This Constitution may be amended by a two-thirds vote at any regular meeting, the amendment having been approved by a two-thirds vote of the Council, taken by letter ballot.

RULES GOVERNING THE COUNCIL.

First. The officers of the Society shall constitute a committee to arrange the time and place of the annual meeting, and also to prepare a program for the same.

Second. The President, Secretary and Treasurer shall constitute an Executive Committee, which shall have charge of all matters relating to the business affairs of the Society not otherwise provided for.

Third. The reading of papers shall be limited to fifteen minutes each, and abstracts of the same of about three hundred words or less shall be printed when practicable and distributed in advance to the members.

Fourth. The time occupied by each person in the discussion of any paper shall not exceed five minutes.

PUBLICATIONS.

The publications of the Society can be obtained from the Secretary, or from the publishers direct. The price of the bound volumes of the Proceedings is $2.50 to non-members, $2.00 to public libraries, and $1.50 to members for their libraries.

Reprints of papers may be ordered when the paper is in type form, with or without covers, at a price depending upon the number of pages and copies desired.

PROCEEDINGS.

Monday, July 2, 1906.

MORNING SESSION, 9:30 O'CLOCK.

The fourteenth annual meeting of the Society for the Promotion of Engineering Education was held in the lecture room of mechanical engineering of Sibley College, Cornell University, Ithaca, New York, July 2 and 3, 1906. The Society met as an affiliated society with the American Association for the Advancement of Science.

The meeting was called to order by the President, Charles L. Crandall, who delivered an address of welcome.

The report of the Secretary, Milo S. Ketchum, was read and accepted. The report of the Treasurer, Frederick P. Spalding, was read, and was referred by the President to an Auditing Committee consisting of Professors Henry S. Jacoby, Henry H. Norris, and Fred Asa Barnes.

The applications of the following persons having been approved by the Council, they were duly elected members of the Society: Byron B. Brackett, John J. Clark, Frank O. Dufour, Frederick G. Higbee, David R. Jenkins, Charles H. Lawrance, Oscar A. Leutwiler, Charles E. Lucke, George N. Mitcham, Charles H. Pierce, Louis Rouillion, Thomas B. Sears, Harold B. Shattuck, Charles F. Shoop, Charles S. Slichter, Earl

B. Smith, Leslie A. Waterbury, J. Burkett Webb, Edson Ray Wolcott.

No business coming before the general session, the literary exercises of the meeting were opened by the delivery of the Annual Address by the President, Charles L. Crandall, Professor of Railroad Engineering and Geodesy, College of Civil Engineering, Cornell University, on "The Graduate School in Engineering Education."

The first paper of the session was on "The Training of a Chemical Engineer," by Henry P. Talbot, Professor of Analytical Chemistry, Massachusetts Institute of Technology. It was read by the author, and was discussed by Professors Norris, and C. F. Allen, Mr. Bassett Jones, Jr., Professor Landreth and the author.

The next paper was the "Report of the Committee on Technical Books for Libraries." As printed copies of the report had been sent to the members before the meeting, the reading of the report was omitted. Professor Arthur H. Ford, a member of the Committee, acted as its representative in the absence of Professor Charles F. Burgess, the Chairman of the Committee. The report was discussed by Professors Van Ornum and D. C. Jackson, Mr. Wiley and Mr. Bassett Jones, Jr., Professors Norris, H. P. Talbot, Magruder, A. N. Talbot, Ketchum, Ford, Tyler, C. F. Allen, and Swain. An author's closure has been added by Professor Burgess. On motion of Professor D. C. Jackson, the report was accepted as a report of progress, and ordered printed in its present form, and the present Standing Committee continued.

The "Report of the Committee on Statistics of

Engineering Education" was next presented by its Chairman, Professor Wm. T. Magruder. It was illustrated by blue-prints. The report was accepted and the Committee continued.

The next paper on the program was by Bassett Jones, Jr., Consulting Engineer, on "The Benefit of Philosophy to the Engineering Student." It was read by the author and was discussed by Professors Landreth, Waldo, F. C. Caldwell, and Marvin, and replied to by the author.

A paper on "The Justification of the Use of the Expression 'Engineering Mathematics,'" by Arthur E. Haynes, Professor of Engineering Mathematics, University of Minnesota, was next presented and was read by the Secretary in the absence of the author. It was discussed by Mr. Bassett Jones, Jr., and by Professors A. N. Talbot, C. M. Woodward, Waldo, Henry T. Eddy, Tyler, Swain, C. F. Allen, Norris, and F. B. Williams.

The "Report of the Committee on Industrial Education" was made by the Chairman, Professor Calvin M. Woodward. It was discussed by Professors Swain, Tyler, Waldo, and the Chairman. It was accepted as a report of progress, and the Committee was continued, to report more fully in 1907.

The last paper of the morning was on "The Dual Degree for Engineering Courses," by Paul C. Nugent, Professor of Civil Engineering, Syracuse University. In the absence of the author, it was read by the Secretary.

AFTERNOON SESSION, 2 O'CLOCK.

The first paper of the afternoon session was by Charles S. Slichter, Professor of Applied Mathematics, University of Wisconsin. Its title was "The Improvement of the Freshman Year of Mathematical Instruction in Technical Schools." In the absence of the author, it was read by the Secretary. It was discussed by Professors Waldo, Norris, Marvin, D. C. Jackson, Landreth, Tyler, J. P. Jackson, and Jacoby.

"The Standing Committee on Requirements for Graduation" reported through its Chairman, Professor Wm. G. Raymond, that the Committee had no report to make this year.

A paper on "The Standards to be Placed Before the Young Engineer," by James P. Munroe, Treasurer of the Munroe Felt and Paper Company, was read by the Secretary.

Henry H. Norris, Professor of Electrical Engineering, Cornell University, then read his paper on "Blank Forms for Use in Electrical Engineering Instruction." The paper was illustrated by samples of the blanks used in the Department of Electrical Engineering, of Sibley College, and was discussed by Professors Brackett, F. C. Caldwell, Ford, R. C. Carpenter, J. P. Jackson, with a closure by the author.

The topical discussion on "Is the Design of Electrical Machinery a Profitable Undergraduate Study" was led by Professor Henry H. Norris. He was followed by Professor D. C. Jackson.

The next paper was on "The Function of the Lecture in Technical Instruction." It was read by the author, John P. Jackson, Professor of Electrical Engineering, Pennsylvania State College. The paper was discussed by Professors Merriman, F. C. Caldwell, Swain, Marston, Norris, Jacoby, C. F. Allen, and the author.

TUESDAY, JULY 3, 1906.

MORNING SESSION, 10 O'CLOCK.

The first paper to be presented was by John F. Hayford, Inspector of Geodetic Work and Chief of Computing Division of the Coast and Geodetic Survey, and was entitled "Why not Teach about Men, the most Difficult Tool an Engineer Uses?" It was discussed by Professors Abbott, D. C. Jackson, Brackett, Marvin, Magruder, C. F. Allen, R. C. Carpenter, Marston, Jacoby, Waldo, Merriman, Turneaure, McNair, Landreth, Swain, J. P. Jackson, and C. M. Woodward. The discussion was closed by the author.

A paper on "The Work in the Mechanical and Electrical Engineering Laboratories of Sibley College" was read by the author, Rolla C. Carpenter, Professor of Experimental Engineering, Cornell University.

"The Federal Polytechnic at Zürich from an Administrative Standpoint" was the title of a paper presented by Harry W. Tyler, Professor of Mathematics, Massachusetts Institute of Technology.

The "Report of the Committee on Entrance Requirements for Engineering Colleges," by Professor John J. Flather, Chairman, was read by the Secretary.

The topical discussion on "What Modifications in Engineering Instruction are Demanded by Recent Advance in Practice" was led by Olin H. Landreth, Professor of Civil Engineering, Union University.

The next paper of the session was by Francis C.

Caldwell, Professor of Electrical Engineering, Ohio State University, and was on the subject of "Fraud in Examinations."

The paper by John J. Clark, Dean of the Faculty, International Correspondence Schools, on "The Correspondence School—Its Relation to Technical Education, and some of its Results," which had been presented and read before Section D of the American Association for the Advancement of Science at its meeting on the Saturday previous, was read by title and ordered to be printed in the Proceedings of the Society.

The Nominating Committee, consisting of Past-Presidents Swain, Merriman, Eddy, Marvin, Woodward, C. F. Allen, and Councilors Waldo, A. N. Talbot, and Reber, made the following report through its Chairman, Professor Swain:

For President: Dugald C. Jackson, Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.

For Vice-President: Rolla C. Carpenter, Professor of Experimental Engineering, Cornell University, Ithaca, N. Y., and Charles S. Howe, President of Case School of Applied Science, Cleveland, Ohio.

For Secretary: William T. Magruder, Professor of Mechanical Engineering, Ohio State University, Columbus, Ohio.

For Treasurer: Anson Marston, Professor of Civil Engineering, Iowa State College, Ames, Iowa.

For Members of the Council whose terms are to expire in 1909: M. S. Ketchum, Professor of Civil Engineering, University of Colorado, Boulder, Col.; J. T. Hayford, Inspector of Geodetic Work and Chief of Computing Division of the Coast and Geodetic

Survey, Washington, D. C.; Henry H. Norris, Professor of Electrical Engineering, Cornell University, Ithaca, N. Y.; C. F. Burgess, Assistant Professor of Electrical Engineering, University of Wisconsin, Madison, Wis.; J. A. Thaler, Professor of Electrical Engineering, Montana College of Agriculture and Mechanic Arts, Bozeman, Mont.; A. M. Greene, Jr., Professor of Mechanical Engineering, University of Missouri, Columbia, Mo.; T. W. Palmer, Professor of Mathematics, University of Alabama, University, Ala.

On motion, the Secretary of the Society was instructed to cast the unanimous ballot of the members present for the list of officers as proposed by the Nominating Committee. He did so, and the Chairman declared them elected.

On motion, the meeting then adjourned.

The following members were present at the meeting and registered: C. Frank Allen, Charles Whiting Baker, B. B. Brackett, A. T. Bruegel, F. C. Caldwell, John J. Clark, C. L. Crandall, F. O. Dufour, Henry T. Eddy, S. S. Edmands, A. H. Ford, Jos. H. Hawes, Dugald C. Jackson, John Price Jackson, Henry S. Jacoby, Bassett Jones, Jr., Milo S. Ketchum, Olin H. Landreth, Wm. T. Magruder, A. Marston, F. O. Marvin, Mansfield Merriman, Henry H. Norris, E. L. Ohle, T. W. Palmer, Louis E. Reber, Edward Robinson, G. F. Swain, Arthur N. Talbot, H. P. Talbot, J. A. Thaler, F. E. Turneaure, H. W. Tyler, W. O. Wiley, Frank B. Williams, Arthur J. Wood (36).

The following members were present at the meeting, but did not register: John H. Barr, Rolla C. Carpenter, John F. Hayford, Charles S. Howe, Fred W. McNair, Calvin M. Woodward (6), and possibly others.

REPORT OF THE TREASURER.

SUMMARY OF RECEIPTS.

Cash on hand, July, 1905	$ 510.56
Current and Future Dues	920.00
Past Dues Collected	114.00
Sale of Reprints to Authors	25.56
Sale of Proceedings	69.52
	$1639.64

SUMMARY OF EXPENDITURES.

Printing and Express, Proceedings	$ 606.53
Expenses, Atlantic City Meeting	124.68
Treasurer's Expenses	50.60
Committee on Statistics	11.65
Secretary's Expenses, 1904–05	39.80
Secretary's Expenses, 1905–06	69.00
Care of Proceedings (Secretary's expenses to Lancaster)	30.00
Reprints for Authors	61.94
Secretary's Honorarium	100.00
Balance, Cash on hand	545.44
	$1639.64

Respectfully submitted,
FREDERICK P. SPALDING, *Treasurer.*

We have examined the accounts of the Treasurer, comparing the vouchers with the items of the above report, and find the same to be correct.

HENRY S. JACOBY,
HENRY H. NORRIS,
FRED ASA BARNES.

ITHACA, N. Y.,
September 6, 1906.

REPORT OF THE SECRETARY.

The membership of the Society has increased from 379 at the beginning of the Atlantic City Meeting to a present membership of 400. With the active coöperation of the members of the Society, the membership should be materially increased.

During the past year the Committee on Technical Books for Libraries has made a report, printed copies of which have been distributed to the members. The numerous requests for the first report of this Committee from libraries and individuals makes it certain that the second report will prove to be of great value.

The work of the Secretary is increasing very rapidly and the question of providing material assistance to this officer of the Society is one that needs consideration.

The Society has lost by death Howard S. Webb, Professor of Electrical Engineering, University of Maine; Lyman Hall, President, Georgia School of Technology, and Albert H. Heller, Professor of Structural Engineering, Ohio State University.

Respectfully submitted,
MILO S. KETCHUM, *Secretary.*

ADDRESS OF WELCOME.

BY CHARLES L. CRANDALL,

Professor of Railroad Engineering and Geodesy, Cornell University.

It gives me pleasure to extend to you the hospitality of Cornell at this the fourteenth annual meeting of the Society for the Promotion of Engineering Education. The Society, organized as an outgrowth of the Educational Congress held at the World's Fair at Chicago in 1893, has grown until its list of about 400 members includes the names of nearly all the leading engineering educators in this country.

During this period it has exerted a very marked influence in the interests of technical education. The reports of its standing committees have done much towards systematizing both the requirements for entrance for the different schools, and the courses of study and the requirements for the various engineering degrees. The papers and discussions together with the printed yearly reports have brought about a clearer conception of the ideals of engineering education and the requirements of engineering practice.

It is not too much to say that this Society has been one of the prominent factors in placing American technical education on a par at least with any in the world.

Cornell is a most appropriate place for a meeting of this Society. Founded under the Morrill Land Grant Act for the Promotion of Agriculture and Mechanic Arts, and opened in 1868, it early developed courses in engineering and the sciences and broke away from the old traditional methods of instruction.

For the scientific departments, the entrance requirements were low and did not include Greek and Latin.

With the growth of the University came the division into colleges as follows:

College of Arts and Sciences,
College of Law,
Medical College,
New York State Veterinary College,
College of Agriculture,
College of Architecture,
College of Civil Engineering,
Sibley College of Mechanical Engineering.

The requirements for admission have been gradually raised so that now they include for engineering, mathematics to analytics, three years of high school English, one history, and two modern languages, one of which can be replaced by Latin, or in part by science. These are equivalent to the requirements in the course in arts.

The civil engineering course includes about 1¼ years of mathematics, science and political economy taught by the College of Arts and Sciences, 2½ years of technical work taught in the college and ¼ year of technical work taught in Sibley College.

About ½ (or 9 count hours) of the senior year is elective.

Laboratories for instruction in engineering were early introduced, the late Dean Fuertes of the College of Civil Engineering claiming to have been the first to make use of them.

During the past year there were 1,086 students in mechanical and 418 in civil engineering, or a total of 1,504 in undergraduate courses.

The instructing force in mechanical engineering includes 7 professors, 8 assistant professors, 22 instructors, and 14 shop foremen and assistants. In civil engineering, 3 professors, 6 assistant professors, and 20 instructors. This gives a total for engineering of 10 professors, 14 assistant professors and 42 instructors beside the shop force of 14.

The total number of students in the university is 3,385.

In conclusion allow me to express my appreciation of the honor conferred upon the University in selecting for its president one who has been identified with the civil engineering department since its foundation, with the exception of 1⅔ years immediately after graduation.

THE GRADUATE SCHOOL IN ENGINEERING EDUCATION.

BY CHARLES L. CRANDALL,

Professor of Railroad Engineering and Geodesy, Cornell University.

The time which the average American student should spend in a technical school has been much discussed both in this society and out of it, and the conclusion seems to be that the limit should be four years. In regard to the time which should be spent in preparation, agreement is not so close. This is in part due to the failure of the preparatory schools to respond to advanced college entrance requirements, thus preventing an increase in the time required for preparation even if desired. There is a marked tendency however to encourage, if not to require, a decided increase in general training for entrance; the effect of this is to relieve the college course of literary subjects and thus give more room for technical ones. The time given to the technical work of the course is thus still on the increase, although the entire college course has a fixed length.

Many students take an A.B. degree before beginning a technical course, requiring six years if the two courses are well correlated or seven if they are not.

The time devoted to education for the engineering profession is thus on the increase despite the four year limit placed upon the technical course.

At the end of this four-year course the average student who may wish to take up advanced work or become an engineering teacher is usually advised to first enter active practice for a few years in order to better appreciate the spirit and field of engineering.

On the other hand many of the large companies employing engineers prefer to take them at this period in order to train them in their methods and for their special needs.

The supply of men is far short of the demand so that no difficulty is experienced in obtaining positions and fairly rapid promotions.

Under these conditions the demand for graduate work must be small. It is however real and a demand which will increase in the near future. The field of engineering is broadening rapidly and its technical requirements are becoming more exacting. This makes necessary a broader and more thorough education and an earlier specialization. When the supply of young engineers again reaches or exceeds the demand, advanced engineering education will be sought as a means for advancement. When the speaker entered the profession, engineering education and a college degree were drawbacks in securing a position. Now they have come to be appreciated by the profession and to be demanded of the young man seeking a position.

To meet the demand for graduate work a large number of our engineering schools have established advanced or graduate courses of study in connection with their undergraduate ones. This is believed to be the natural and desirable line of development. The dividing line between undergraduate work as carried on at our best schools and graduate work is not sharply defined. With the great variations in undergraduate courses at the different schools, many students will come for graduate work who will wish to round out their undergraduate course. The graduate school will elevate the ideals and aid in vitalizing the work of the undergraduates, acting on both the faculty and students. Much of the apparatus can be used in common, while many members of the faculty would give instruction and look after the needs of both.

The development for civil engineering at Cornell University may be of interest as somewhat typical for the American school.

At the opening in 1868, the degree of B.C.E. was provided for the four-year course, which was about one third technical and two thirds science and general culture. The master's degree of C.E. could be obtained after two years of additional study and practice by passing the requisite examinations. Twenty advanced degrees were taken on this basis between 1868 and 1891 inclusive.

In 1880–1 a one-year prescribed course of resident graduate study with free tuition was added as an alternate for the two years of additional study and practice, but no C.E. degree was ever conferred on this basis.

In 1885–6 the degree for the four-year course was changed to C.E. and the graduate course was replaced by prescribed courses in six different specialties, the student taking his choice between them. Seven university graduate fellowships of the value of $400 each were established in 1884–5. This number was increased to fifteen in 1891–2.

The first master's degree for resident graduate work was granted in 1890–91, and this should be taken as the date for the beginning of graduate work in civil engineering at Cornell. Since that time 34 master's degrees have been granted, about one half for resident graduate work and the other one half for non-resident. Tuition for graduate study was added in 1893–4 and this has cut off all non-resident study for the master's degree.

The college now has one graduate fellowship paying $500 and one graduate scholarship paying $400. No prescribed graduate courses are offered. The student chooses a major and one or two minors under the general regulations of the graduate department of the university and he is looked after by a special committee consisting of the professors in charge of the major and minor subjects.

Our students are also eligible for, and several have taken, the degree of Doctor of Philosophy under the same general system as for the master's degree.

From such catalogues as were available, representing seventeen of the leading civil engineering schools of this country giving graduate courses, we find there were teaching civil engineering subjects for the year 1905–6:

50 full professors, or an average of 3 per school, the greatest number being 5, the least 1.

24 assistant and associate professors, average 1.5; or 74 professors, average 4.5, greatest 9, followed by two of 7 each, three of 5 each, and two of 4 each.

58 instructors, average 3.4; greatest 20, least 2.

43 assistants, average 2.5; greatest 10, least 0; or 101 instructors and assistants, average 6.

Professor C. D. Marx, in a private pamphlet prepared for Cornell University last year, gives the following data for the civil engineering departments for three of the German technical schools for the summer session of 1905.

	Advanced Students.	Undergraduate Students.	Professors.	Private Docents.	Assistants.	Docents.
Technische Hochschule, Berlin*	146	415	14	8	—	—
Technische Hochschule, Aachen	21	67	7	—	5	—
Technische Hochschule, Danzig...........	64	44	6	—	1	1

*** These figures do not include instructors and assistants, nor those professors teaching mathematics, mechanics and descriptive geometry.**

The Berlin school was established as a "Hochschule" in 1879. The school at Aachen was founded in 1870, and that at Danzig was opened for instruction in October, 1904.

The best of our civil engineering technical schools compare favorably with those at Aachen and Danzig as to the number of professors per school or per graduate student, but not as to the number of professors per total number of students. We have nothing to compare as to number of professors with the school at Berlin, the tendency here being to provide for additional students not by additional professors but by instructors and assistants. This tendency has been carried too far in all or nearly all our large schools with the result of lowering the grade of instruction.

On the whole the comparison warrants the belief that our existing schools are ready to meet, if not to anticipate, the demand for high grade advanced work as rapidly as it develops.

Some of the characteristics of German technical education are well brought out by Mr. Bashford in the *Fortnightly Review,* Vol. 84, 1905. He says that "there is no example in the history of education that can be compared with the rapid and extraordinary progress of technical education that has taken place within the last thirty years in Germany." "They have all along recognized the bearing of science upon industry." "Germany has ten technical universities, viz., at Aachen, Hanover, Berlin, Danzig, Dresden, Brunswick, Munich, Karlsruhe, Darmstadt, and Stuttgart." "The number of students at all these ten universities now exceeds 17,000." "The aim of the German technical universities is to afford a higher training for the technical calling, and to cultivate those arts and sciences which belong to the field of technical instruction."

"The fees for lectures and laboratory work will not exceed £15 to £17 10s."

"The Minister of Education in Prussia has introduced a plan for selecting men as professors who have distinguished themselves as *practical* engineers, and who combine a solid foundation of the knowledge of the theory of their work with sufficient practical experience."

Mr. Vanderlip in *Scribner's Magazine,* Vol. 37, 1905, says, "The theory of education in Germany has been that it should be the work of the government schools to turn out the most efficient economic units, while the task of the captains of industry was to organize these units into the most effective economic corps possible." "Germany is a land of small salaries, and we are supposed to be ready to pay more than any country for the desirable services of any man. I was surprised, therefore, to learn that we could not attract some of the great professors of industrial chemistry to our own institutions, because we could not pay salaries that would approach the salaries which they received in Germany." "A professor of industrial chemistry in one of the great technical schools will not only be regarded as a leader in scientific circles, but he will occupy an intimate and most remunerative relation towards industrial enterprises. I was told that the professor of industrial chemistry in the technical high school of Charlottenburg received a salary of $25,000 a year." "The higher remuneration in Germany is possible because of the intimate relation which has been built up between the schools and the great industries. The problems which came before the managers of these industries are laid before the technical schools, and the schools are well paid for solutions of these problems. Then, in turn, industry flourishes because of the superior methods which these technical experts invent."

In studying the German system we can note with most advantage the close relation between the schools, the industries and the profession, the professor being a specialist able to direct design and research in accordance with the best in practice.

Waddell's well-known address on Higher Education for Civil Engineers, published in his Professional Papers, contains some valuable suggestions. He thinks that the time is not far distant when the first-class course in civil engineering will occupy five years.

For the post-graduate course he would have a comparatively small corps of permanent professors and have most of the instruction given by practicing engineers who were the best known and most competent in the profession. Original investigation by both the professors and the students should be provided for and encouraged in every way and the results published by the institution. These investigations should tend to improve engineering practice or lead to valuable discoveries in technical science. A large and complete testing laboratory should be in use as part of the curriculum, while designing should be the method of instruction as far as practicable. He would have the graduate school separate from the undergraduate.

In conclusion it may be said that the present demand is for men better trained in the undergraduate or four-year course, men with broader general education and high ideals who are well grounded in mathematics, economics and the sciences as applied to engineering. Technical skill is also demanded, but capacity for development is the essential requisite.

The experience of Col. Prout as expressed in an address at the reunion of the Cornell civil engineers last year is significant. He says that "it is my constant observation of four engineering works, employing about 20,000 men, that the engineers reach the limit of their usefulness from defects of character, rather than from want of technical attainments. Our greatest difficulty is to find courage, candor, imagination, large vision and high ambition. I do not know which of these qualities is most often lacking, or which is most essential. The lack of courage and candor comes most often to my notice, but the lack of imagination and of broad outlook produces the most serious disasters."

In meeting this demand for undergraduate work many of our schools have secured an instructing force and an equipment suitable for investigation and graduate work. The number of students, graduate and undergraduate, doing advanced work is relatively small, but it is on the increase. The number engaged in research work in the universities with which many of the schools are connected is also on the increase. At three of the leading German engineering schools, 29 per cent. of all the civil engineering students attending the summer session last year were taking advanced work and 32 per cent. of those in mechanical and electrical engineering.

This leads to the belief that the demand must steadily increase here.

The method of instruction by design and research under the direction of specialists who are consulting engineers of high standing in practice, as advocated by Waddell, is difficult of execution even when the consulting engineer is relieved of most of the detailed work of instruction by a resident assistant. The successful consulting engineer who is at the same time a good teacher and who is willing to scatter his forces between the two is rare.

The writer believes that the engineering professor should be first of all a teacher. He should also be an engineer. Many of our most successful teachers even for advanced work are familiar with the needs of practice and the border line of engineering knowledge through engineering literature, contact with engineers and research work at the school, rather than from actual practice in recent years. Many of our successful teachers are however consulting engineers.

THE TRAINING OF A CHEMICAL ENGINEER.

BY HENRY P. TALBOT,

Professor of Inorganic and Analytical Chemistry, Massachusetts Institute of Technology.

Chemical engineering is probably the latest, and seemingly the least well-defined of the various phases of the engineering profession. The civil, the mechanical, the mining, the electrical, and the sanitary engineer, each occupies a recognized position, and the scope of his profession is quite definitely delimited in the public mind. But the query is not uncommonly propounded, "Just what is a chemical engineer?" and the answer is not easily put in a concise form.

The chemical engineer may be defined as a person with a thorough, fundamental knowledge of chemistry, theoretical and applied, who also possesses such a knowledge of engineering theory and practice as to be able to transform the reaction of the notebook and the laboratory into a commercial plant, capable of operation on a technical scale and at a financial profit. His profession, as distinct from that of the chemist on the one hand, or the engineer on the other, is in part an outgrowth of the largely increased investment of capital in plants of great size and productive capacity, which has created a demand for men to fill the various positions involving superintendence and responsibility who have such an insight into the domain of both engineer and chemist that they can give general direction to the work and understand what may be properly required of each, and can render the results obtained in the laboratory effective by the incorporation into the works of the necessary apparatus for operation on a commercial scale.

Two other factors have also contributed to the demand for the chemical engineer with his capacity for a broad general oversight, namely, the pressure of the demand for greater refinement of product which is increasingly felt by the manufacturers, and the necessity for the greatest economy of labor, power and materials. The waste product of yesterday, often a source of great annoyance, has become a source of profit to-day through such an intelligent criticism of a plant, and through such cooperation between its various parts as the chemical engineer can supply.

If this summary is accurate, it is at once evident that the training for such a profession must be of the broadest type, and that it must involve a most careful selection from among an almost bewildering variety of subjects; for the chemical engineer must, beside being a chemist—and hence something of a physicist, mathematician and linguist—also be something of a mechanical engineer, and cannot altogether neglect the problems of electricity in its commercial bearings.

Whether all these can be adequately provided for in four years may be doubted. Five years would unquestionably be better, but the popular demand requires that the effort shall be made to solve the problem as best it may be met in four years, and in what follows it is assumed that only this period is allowed.

Assuming that the chemical engineer is a combination of the chemist and the mechanical engineer, should his training be mainly that of a chemist, or mainly that of an engineer? Opinions will doubtless diverge somewhat at this point. A careful consideration of this question, and a somewhat extended conference with employers of industrial chemists, as well as with practicing chemists themselves, led the writer to the conclusion that the main stress should be laid upon the chemical side in a course of training for a chemical engineer in a college or technical school, and this for two reasons:

First, because the man at present demanded by the chemical industries and those involving chemical processes must apparently be primarily a chemist in the proper use of the term; and,

Second, because, if either chemical or engineering subjects must be acquired in part after graduation from the systematic instruction of the classroom and laboratory, engineering subjects are more easily handled, provided the foundation for such independent study has been well laid. In a four-year course, then, the proportion of time devoted to chemical subjects should exceed that given to engineering subjects, possibly even in a ratio of three to two.

The chemical instruction must necessarily be general and fundamental rather than specialized. It should include general inorganic chemistry, for a year, possibly merging into qualitative analysis, which subject should also occupy a succeeding half year. The instruction in quantitative analysis should aim to train accurate, intelligent, critical analysts, rather than men with simply a knowledge of methods, and should, if possible, include problems of proximate as well as ultimate analysis, to develop ingenuity and self-reliance. Organic chemistry should be thoroughly taught through lectures, recitations and laboratory practice, and theoretical and physical chemistry, also with accompanying laboratory practice, should be continued through at least one year of the course.

All of the foregoing fundamental subjects should be presented essentially from a "pure science" standpoint (although the wise teacher will vitalize his instruction by frequent recourse to his own professional experiences), and the young man who is in training for the industrial arena should be made to feel that he will find the apparently non-technical phases of the science the mainstay of his professional work. But there should also be a course in industrial, or applied chemistry, in which the technical aspects of the science are frankly treated. Such a course should best be given by an instructor of some maturity and with experience gained in technical positions, through service as an expert, or by frequent visits to operating plants. In the lecture room, details of methods should be carefully subordinated to the presentation of types of apparatus or processes, with the underlying reasons for their selection to secure a given result, and no opportunity should be lost for a demonstration of the application of the so-called theoretical chemical principles in commercial practice. This classroom instruction should be accompanied by and coordinated with a laboratory course which should be so conducted as to bring to the student a realization of the meaning of what has been called the "economics of chemistry." Such a course has been fully described by Dr. W. H. Walker in the *Technology Review* (Vol. 6, page 163). The experiments "are selected not so much for their intrinsic merit or relative importance as for the ease with which they may be adapted to laboratory conditions and the exactness with which the several factors making up their final efficiency may be controlled." Some of these factors are cost of materials, cost of reagents, mechanical difficulties to be overcome and types of apparatus and kinds of material available, the control of reactions involved, the use of scientific tables in technical work, the use of instruments of technical accuracy little known in other lines of work, the value of waste or wash liquors and their utilization, the purity of the product, and the presentation of a systematic report. Such factors as the cost of labor or power, the depreciation of plant, or interest on investment, are not, of course, directly subject to determination in the laboratory but these are taken up and discussed in conference. The work is further arranged in such a way that several students will work simultaneously upon a given problem, a single factor being altered by each, the final results being discussed in conference, and in all this the spirit of investigation is carefully fostered.

In a course of this character, no claim is made that actual industrial conditions are duplicated; it is the industrial trend of the course which constitutes its value, and the things which it suggests and the points which it raises for discussion and conference are its vital features. These suggestions are avowedly based upon work which has been carried out upon a very small scale in comparison with an industrial plant, and many of the problems of the latter can necessarily only be dimly realized by the student.

Another suggestion has been made that a small plant, composed of units from a limited number of larger chemical plants for the production of such products as muriatic or nitric acids, or electrolytic bleach liquor should be established, and operated by students. This contemplates a closer approach to working conditions, and would possess certain unquestionable advantages. Against these must, however, be placed the very considerable cost of housing, establishment and maintenance of a plant of this sort, the present (although not insuperable) difficulties in adapting the work in such a plant to the schedules of the college year, and the fact that this would, after all, be but another stage in the progress toward actual industrial conditions, without having attained them. Just where the balance between these considerations would lie is a question which deserves the serious thought of those entrusted with the charge of chemical instruction.

As a preparation for the chemical and the engineering sides, and of about equal importance to both, there must necessarily be included in a course of chemical engineering such mathematical subjects as advanced algebra, trigonometry, analytic geometry, and differential and integral calculus, to which, for the benefit of the instruction in thermodynamics, differential equations might well be added if time permits.

Similarly, a thorough course of instruction in physics of at least a year's duration and made up in part of laboratory practice is a prime essential to the success of the chemical or engineering subjects and should come not later than the second year of the course. Mechanics, light, heat, and electricity, will naturally take up the main portion of the time devoted to this science.

The subjects to be included on the engineering side will necessarily depend upon the residual, available time. Descriptive geometry will doubtless be found an early requisite, and this may be followed by courses in mechanism, applied mechanics, and thermodynamics and steam engineering, which will, of course, be accompanied by the needful practice in mechanical engineering or boiler drawing, and by work in an engineering laboratory. These courses could all be adapted somewhat to the special needs of the student of chemical engineering, but their primary purpose should be to deal with the subject matter so fundamentally and thoroughly, that they may furnish, so far as they go, a safe foundation for later, independent effort and study. The instructor will, if he be wise, naturally draw his illustrations mainly from those types of machines, engines, boilers, furnaces, evaporators, or what not, with which his student is most likely to come into contact, and the drawing required will be selected with some reference to its direct helpfulness. The choice of details for such courses may better be left to the engineering departments than be suggested by one who must view the matter essentially from the standpoint of the chemist.

In addition to all that has been outlined, time must be found for instruction in French and German, so essential to the chemist. Two years of instruction in each language will probably be required, one of which may, however, be relegated to the preparatory school.

There must also be some provision for the acquisition of a little skill in metal working, and in the handling of electric currents of commercial magnitude; and some knowledge of methods of hydraulic measurements is desirable, if possible.

The term "training" which has been employed in the foregoing should be interpreted in a broad sense, for no course can be wholly successful which is not one of education rather than mere training or drill. It is assumed that the instruction in the fundamental subjects enumerated will be given upon broad lines, and in addition there should be opportunity somewhere near the close of the course for a piece of research work on the part of the student which will let him discover his ability, if he possesses it, to grapple with new problems and to rely on himself. The time available for such work will probably be short, perhaps 200 hours, and the problem will not probably be one of epoch-making character; but, if it is conscientiously dealt with, it will mean that the student goes out into his technical career with greater confidence in himself to meet untried conditions.

No reference has been made to so-called cultural studies, or to economics or business law, as these, although of great importance, lie somewhat outside of the scope of the present paper.

It scarcely needs to be reiterated that the training of a chemical engineer demands five years rather than four, and it seems clear that our students should be encouraged to spend an additional year whenever that is possible. Such a year may well be devoted to the development of their training on the mechanical side, including a somewhat larger experience in shop-work, drawing, engineering laboratory, and such additional subjects as machine design, mill-management, etc., while such chemical subjects may be taken as will lead to a more specialized knowledge of that science. The work accomplished in such a post-graduate year may well be of a character which entitles it to recognition by the awarding of a master's degree, thus giving it additional attractiveness.

DISCUSSION.

PROFESSOR NORRIS: I would ask Professor Talbot if his idea is that a man can be both a satisfactory chemical and a satisfactory electrical engineer, that is to say, can one of these large electro-chemical plants get along with but one man?

PROFESSOR H. P. TALBOT: I hardly think that a graduate from a course in chemical engineering can be both a well-trained chemical engineer and a well-trained electrical engineer with but four years of study. A course of this length may, however, be planned with the expectation of training him thoroughly in chemistry, and giving him such a fundamental knowledge of mechanical or electrical engineering that he can get a start in these lines from which he can develop himself according to the demands of his work. The problems confronted in laying out such a course are like those met with in a course of sanitary engineering, where something of chemistry and biology must be included with the civil engineering requisite for success in the field of sanitary work, and four years scarcely suffice for the mastery of even the fundamental notions of this variety of subjects.

Formerly the course in chemical engineering at the Massachusetts Institute of Technology was essentially one of mechanical engineering, with an amount of chemistry added which bore about the same relation to the total time that the mechanical engineering subjects bear to-day. The change was made primarily because it appeared to us that the present demand for men to occupy positions which may be regarded as those of chemical engineers requires that they shall have been educated primarily as chemists rather than as engineers.

PROFESSOR NORRIS: My question was, can one engineer operate a moderate-sized electro-chemical plant?

There is the question of getting the material through the plant economically and that is a mechanical engineering problem.

Professor H. P. Talbot: The technical field has become so largely subdivided that there are many phases which require specially trained men. My idea is that such a man as has been spoken of would ultimately meet requirements even if he did not do so immediately upon graduation, because he would acquire considerable knowledge after he had entered actual service. If I understand your question, the man you refer to should be in a position to act as superintendent, and it may be an open question whether he should not have been trained as a mechanical engineer and have acquired his chemistry afterward, but a chemical engineer trained as I have described might still, I think, fill the position after he had acquired additional practical engineering experience.

Professor Norris: A man must grow to be an engineer. It takes five or ten years to do so.

Professor C. F. Allen: I agree with what has been said and I have in mind a friend of mine who is engineer for one of the most important chemical companies in the country, and who considers himself a chemical engineer. He is a graduate of one of the Eastern colleges, not the one with which I am connected. He was graduated as a civil engineer, but he has had the fundamental training; his work is largely that of a mechanical engineer; he occupies a position that I take it is not easily filled. He succeeded, of course, because he had good training.

Mr. B. Jones, Jr.: In his paper Professor H. P. Talbot spoke of the popular demand for a course not

extending over more than four years. If we all believe that the public is wrong in this, and that a proper modern professional education cannot be encompassed in the shorter period, then it is our duty to insist upon what we know to be right, and not to allow the efficiency of our schools to be decreased by any pandering to public opinion. It is the duty of the teacher to mould public opinion, and when the public is wrong it is the business of the teacher to set it right.

It is unfortunate that financial necessities have often been the dominating influences in education, but if we are to succeed in giving our young men the right sort of education, we must have the courage of our convictions and carry out our ideas regardless of the cost to ourselves. A little reflection will show that the men who have done most to benefit the world have always been men of strong ideas and great moral courage; men who have always been ready to sacrifice themselves in furthering the right.

PROFESSOR LANDRETH: The problem of the best and most efficient organization in the management of constructive and industrial operations has been before the engineering profession long and often. One of the latest forms of the question concerns the proper organic relation of the engineer to the architect in the construction of extensive buildings which require the services of both in their design and erection. In such cases, shall the architect be supreme and the engineer subordinate, or shall the order be reversed? Shall each be independent, or co-ordinate, in authority? Other forms of the question concern the engineer and his work in the maintenance-of-way department of railways, the organization of the technical force in

manufacturing establishments, and the personnel of important public commissions dealing with technical matters.

Without attempting to indicate or suggest in detail the proper status of the engineer in the various situations in industrial activity or to predict the outcome of the consideration which these problems are now receiving, it may be stated as an accomplished fact, not likely in general to be changed, that industry in every great and successful enterprise is carried out under the direction of *one man* having more or less absolute authority and held responsible more or less closely for results. He is the *selector* as well as the *director* of his aids and specialists, but is not a specialist himself, unless we may speak of him as a specialist in the exercise of administrative functions. In all such enterprises the highly skilled and special work must be done by specialists and they are, of course, essential to the success of the enterprise; but it is equally important that there should be men forming the skeleton of the scheme of organization who stand in the direct line of authority and responsibility and who in this relation are the subordinates of their superiors and the superiors of their subordinates. The proper exercise of the functions of these men calls for a knowledge and ability quite distinct from that of the specialists. In place of a highly specialized knowledge of all the subjects under their authority, which is impossible, they must possess a sufficiently full and accurate acquaintance with the subjects to enable them to properly correlate and direct the work of the specialists, and to do this successfully they must be able by their broad knowledge of the field to view the closely specialized work of

the various kinds under their direction in the proper perspective and must maintain the proper proportion and relations between them. In addition to this general and comprehensive knowledge, these men must also possess and exercise executive ability of a higher or lower order according to their nearness or remoteness from the head of the organization.

This last position is the true place for the engineer. A man who is much less than an engineer may make a successful specialist in a narrow field even though technical skill of a very high order in that field is essential. While it is largely a question of notation whether we consent to call this specialist also an engineer, or in general where we would draw the line in notation, there would appear some propriety in reserving the word *engineer* for the man in general who possesses the creative faculty; who by his familiarity with the horizon perceives the proper relation of the things with which he deals and is able to use them intelligibly in his creations; who can design and construct; who can originate and execute, and if need be can operate and administer as well.

REPORT OF COMMITTEE ON TECHNICAL BOOKS FOR LIBRARIES.

BY CHARLES F. BURGESS, Chairman.

In 1901 a committee was appointed by the Society to prepare a list of scientific and technical books as an aid to librarians, and the work of that committee, which extended over a period of two years, was embodied in the report submitted at the meeting in 1903. This list of books was widely distributed as reprints furnished by the Society and also through the assistance of the McClurg Company of Chicago, who edited the list and gave it a wide circulation throughout the country, sending it not only to librarians, but to mechanical, electrical and mining engineers throughout the United States, Mexico, Central America, and other countries.* From a large amount of evidence, both direct and indirect, it appears that the work which was thus undertaken by our Society has been of value to the reading public and to technical men.

There has been a great and insistent demand for the revision of the book-list with the idea of enlarging its scope and bringing it up to date, and it is this work which your committee, appointed last year, has attempted to do. The list previously published comprised 385 titles, and the list which is here presented has been increased to 494. Some few books have been eliminated from the previous list, but the larger part of the changes have been in the nature of addition of new and important books.

The list as it now stands is capable of being very materially improved and by ways which are apparent to the members of your present committee. It is felt that a marked improvement might be effected by further attention to books of the more elementary kind, but to improve this part of the list would require a greater expenditure of time than it has been possible for the members of the committee to devote to it. It is an easier matter to evaluate the more advanced books relating to science and technology than it is the more elementary ones and it is, perhaps, for this reason that the percentage of books in the class "A" is somewhat smaller in the list now offered than it was in the one previously presented.

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* The McClurg Co. has reprinted this report. 1907.

It is also suggested that should a committee be appointed at this meeting to continue this work, a material improvement in the list could be effected by adding a considerable number of books relating to manufactures, trades, and chemical technology.

It is believed, however, that should the list grow beyond 500 titles, it would become unwieldy. If we should adopt for our standard a list of 500 titles, it could be made of permanent value through a yearly process of substitution of the new books which may prove themselves better than those already on the list. The work of a standing committee whose duty it is to make such corrections ought not to be nearly so arduous as has been the work of the committees thus far.

Wm. H. Kavanaugh,
A. H. Ford,
James Fisher,
H. K. Vedder,
J. H. Hawes,
C. F. Burgess, *Chairman,*
Committee.

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EXPLANATORY SYMBOLS.

The publications in this list are designated by the letters *A*, *B*, *C*, and *D*, to indicate something of the nature of the books and the class of readers for which they are particularly suited. The classification is as follows:

A. Books of elementary nature containing no mathematics and written in the simplest form; for boys, amateurs, and others having no previous knowledge of the subject.

B. Books treating the subject from the popular standpoint and written in such a manner as to be of general interest.

C. Books treating of details of practical application of science and engineering; suitable for city officials or others interested in municipal affairs, manufacturers, mechanics, artisans, students in manual training, and as preparatory for more advanced work.

D. Representative advanced books for engineers, designers, surveyors, etc.

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Draftsman, Cleveland	Monthly	1.00
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Engineering, London	Weekly	10.00
Engineering and Mining Journal, New York	Weekly	5.00
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Machinery, New York	Monthly	1.00 & 2.00
Marine Engineering, New York	Monthly	2.00
Marine Review, Cleveland	Weekly	3.00
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Municipal Journal and Engineer, New York	Monthly	3.00
Pattern Maker, Cleveland	Monthly	1.00
Power, New York	Monthly	2.00
Proc. American Soc. Civil Engineers, New York	Monthly	9.00
Proc. New York R. R. Club, New York	Monthly	1.00
Proc. St. Louis Rwy. Club, St. Louis	Monthly	1.00
Proc. Western Rwy. Club, Chicago	Monthly	2.00
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Railroad Master Mechanic, New York	Monthly	1.00
Railway Age, Chicago	Weekly	4.00
Railway and Engineering Review, Chicago	Weekly	4.00
Railway and Locomotive Engineering, New York	Monthly	2.00
Scientific American, New York	Weekly	3.00
Scientific American Supplement, New York	Weekly	5.00
Sibley Journal of Mechanical Engineering, Ithaca	Monthly	2.00
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Stone, New York	Monthly	2.00
Street Railway Journal, New York	Weekly	4.00
Trans. Am. Inst. Electrical Engineers, New York	Monthly	

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C, D. Langbein, Dr. Geo. A Complete Treatise on the Electrodeposition of Metals. Carey, Baird & Co. $4.00.

Comprising electro-plating and galvanoplastic operations, the deposition of metals by the contact and immersion processes, the coloring of metals, the methods of grinding and polishing, etc.

C, D. Lyndon, L. Storage Battery Engineering. McGraw. Net $3.00.

A practical work devoted to designing, installing and maintaining battery equipments.

C, D. MacMillan, W. G. A Treatise on Electrometallurgy. London. Net $3.65.

A, C. Marshall, Percival. Accumulators: How Made and Used. Spon. $0.50.

A practical and fairly accurate description for those wishing to construct small storage batteries. Not exhaustively nor scientifically treated.

C. Treadwell, Augustus, Jr. The Storage Battery. Net $1.75.

The construction, theory and use of secondary batteries.

B, C. Trevert, E. Practical Hand-Book of Electroplating. Bubier. $0.50.

MISCELLANEOUS APPLICATIONS OF ELECTRICITY.

A, C. Bottone, S. R. Electric Bells and All About Them. $0.50.

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With constructional and manipulatory details.

C, D. Dawson, P. Engineering and Electric Traction Pocket Book. Flexible leather. $5.00.

C, D. Foster, Horatio. Electrical Engineers' Pocket Book. Flexible morocco. $5.00.

Tables, data, and formula relating to all branches of electrical application.

C. Meadowcroft, W. H. A B C of the X-rays. $0.75.

C. Norrie, H. S. Electric Gas Lighting. $0.50.

How to install electric gas lighting apparatus, including the jump spark and multiple system.

A, C. Norrie, H. S. Induction Coils. $1.00.

Methods of making induction coils and their uses for gas engine igniters, X-ray work, etc. Practical rather than theoretical.

D. Roentgen, Stoke, and Thompson, J. J. Roentgen Rays. Net $0.60.

A. Trevert, Ed. How to Make and Use Induction Coils. $0.50.

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C. Brookes, L. E. The Automobile Hand-Book. F. J. Drake & Co. $1.50.

Contains practical information for the use of owners, operators and automobile mechanics.

B, C. Chanute, O. Progress in Flying-Machines. American Engineer and Railroad Journal. $2.50.

C. Dyke, A. L., and Dorris, C. P. Diseases of a Gasoline Automobile and How to Cure Them. A. L. Dyke Automobile Supply Co. $1.50.

B, C, D. Hasluck, Paul. The Automobile; Its Construction and Management. London. $4.50.

B, C. Hiscox, G. D. Horseless Vehicles, Automobiles, Etc. Henley. $3.00.

A practical treatise on the use and care of the automobile.

C, D. Homans, J. E. Self-Propelled Vehicles. Audel. $2.00.

A practical treatise on the theory, construction, care and management of automobiles.

C, D. White, T. H. Petrol Motors and Motor Cars. Longmans. $1.50.

Good book for designers of motor cars and engines for same.

C, D. Woods, C. E. Electric Automobiles; their care, construction and operation. Stone. $1.25.

B, C. Young, A. B. F. The Complete Motorist. McClure, Phillips & Co. $3.50.

An account of the evolution and construction of the modern motor-car.

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D. Brough, B. H. A treatise on Mine Surveying. J. B. Lippincott Co. $2.25.

C, D. Foster, C. L., and Cooke, L. H. Ore and Stone Mining. Griffin & Co. $10.00.

A, B. Frazier, S. M. Secrets of the Rocks. A book especially for prospectors. Engineering and Mining Journal. $1.60.

C, D. Kerr, Geo. L. Elementary Coal-Mining. London. $1.25.

C, D. Lock, C. G. W. Miners' Pocket Book. $4.00.

C, D. Lupton, A., Parr, G. D. A., and Perkins, H. Electricity as Applied to Mining. Van Nostrand. $3.50.

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C, D. Orton, J. Underground Treasures. $1.50.

C, D. Pamely, C. Colliery Managers' Hand-Book. Lockwood. $8.00.

C, D. Richards, R. H. Ore Dressing. 2 Vols. Engineering and Mining Journal. $10.00.

A, B, C. Shinn, C. H. Story of the Mine. Appleton. $1.50.

B, D. Spurr, J. E. Geology applied to Mining. Engineering and Mining Journal. $1.50.

Of practical value to the mining man and others interested in economic geology.

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C, D. Bosqui, F. S. Practical Notes on the Cyanide Process. Illustrated. Scientific Pub. Co. Net $2.50.

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C, D. Campbell, H. H. Manufacture and Properties of Iron and Steel. Scientific Pub. Co. Net $5.00.

C, D. Collins, H. F. The Metallurgy of Lead and Silver. Lippincott. $4.50.

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C, D. Harbord and Hull. Steel, Its Metallurgy and Mechanical Treatment. Griffin. $9.00.

A most exhaustive and practical treatment.

C, D. Hiorns, A. H. Iron and Steel Manufacture, a Text-Book for Beginners. 3d ed. Macmillan. $1.00.

C, D. Hixon, H. W. Notes on Lead and Copper Smelting and Copper Converting. The Scientific Publishing Co. $3.00.

C, D. Hoffman, H. O. Metallurgy of Lead and the Desilveration of Base Bullion. $6.00.

D. Howe, H. M. Iron, Steel and Other Alloys. Sauveur & Whiting. $5.00.

C, D. Ingalls, W. R. The Metallurgy of Zinc and Cadmium. Engineering and Mining Journal. $6.00.

C, D. Peters, E. D. Modern Copper Smelting. Scientific Pub. Co. $5.00.

D. Philips, J. A. Elements of Metallurgy. Lippincott. $8.00.

C, D. Roberts-Austen, Sir. Introduction to the Study of Metallurgy. London. $5.50.

C, D. Rose, T. K. The Metallurgy of Gold. Lippincott. $6.00.

A, C. Sexton, A. H. An Elementary Text-Book of Metallurgy. Lippincott. $2.25.

D. Turner, T. The Metallurgy of Iron. Lippincott. $4.50.

C, D. West, T. W. The Metallurgy of Cast Iron. Spon. $3.00.

CHEMISTRY.

C, D. Bayley, T. Chemists' Pocket Book. Flexible Morocco. Spon. $2.00.

Tables, data, and formulas for use in the chemical industries.

C, D. Blair, A. A. Chemical Analysis of Iron. Lippincott. $4.00.

A complete account of all best known methods for the analysis of iron, steel, pig-iron, iron ore, limestone, slag, clay, sand, coal, coke and furnace and producer gases.

C, D. Bloxam, A. G., and Blount, B. Chemistry for Engineers and Manufacturers. Lippincott.

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Vol. II. The Chemistry of Manufacturing Processes. $4.00.

D. Brearley, H., and Ibbotson, F. Analysis of Steel-Works Materials. Longmans. $5.00.

Contents: The analysis of steel, pig-iron, steel-making alloys, rapid analysis of the furnace, ores, refractory materials, slags, fuels, engineering alloys, boiler water, boiler scales, etc., pyrometry, etc.

C, D. Brown, W. L. Manual of Assaying; Gold, Silver, Lead and Copper. E. H. Sargent & Co., Chicago. $2.50.

C, D. Davis, Geo. E. Hand-Book of Chemical Engineering. Two vols. Manchester. $12.40.

C, D. Furman, A. V. Manual of Practical Assaying. Wiley. $3.00.

B, C. Furneaux, W. Elementary Chemistry. Longmans. $0.80.

An interesting and practical book dealing with the chemistry of common things.

D. Groves, C. E., and Thorp, W. Chemical Technology, or Chemistry in its Applications to Arts and Manufacturers. Four vols. Blakiston. $16.00.

D. Jervis, W. P. Encyclopaedia of Ceramics. New York. $6.50.

B, C. Johnson, J. F. The Chemistry of Common Life. Appleton. $2.00.

B, C. Lassar-Cohn, Dr. An Introduction to Modern Scientific Chemistry. Van Nostrand. $2.00.

In the form of popular lectures; suited for university extension students and general readers.

B, C. Lassar-Cohn. Chemistry in Daily Life. Translation by Pattison Muir. H. Grevel & Co. Van Nostrand. $1.50.

A series of twelve popular lectures.

C, D. Leffman, H., and Bean, W. Examination of Water for Sanitary and Technical Purposes. Blakiston Son Co. $1.25.

Small but complete.

B, C. Newth, G. S. Chemical Lecture Experiments Non-Metallic Elements. Longmans, Green & Co. $2.00.

C, D. Newth, G. S. A Text-Book of Inorganic Chemistry. Longmans, Green & Co. $1.75.

C, D. Phillips, Joshua. Engineering Chemistry. London. $4.50.

A practical treatise for the use of analytical chemists, engineers, iron-masters, iron-founders, students, and others, comprising methods of analysis and valuation of the principal materials used in engineering work, with numerous analyses, examples and suggestions.

C, D. Prescott and Johnson. Qualitative Chemical Analysis. Van Nostrand. $3.50.

C, D. Remsen, I. Inorganic Chemistry. Advanced course. Holt. $2.40.

C, D. Richter, Victor Von. Organic Chemistry. Tranlalations by Edgar F. Smith. Blakiston & Son. $6.00.

C, D. Sadtler, S. P. Hand-Book of Industrial Organic Chemistry. Revised edition. Lippincott. $5.00.

Adapted for the use of manufacturers, chemists, and others interested in the manufacture or utilization of organic materials.

C, D. Thorp, F. H. Outlines of Industrial Chemistry. 2d edition. Macmillan. $3.50.

A brief description of the more important chemical processes omitting details.

CIVIL ENGINEERING.

D. Baker, I. O. A Treatise on Masonry Construction. Wiley. $5.00.

D. Buel, A. W. and Hill, C. S. Reinforced Concrete. Engineering News Pub. Co. $5.00.

C, D. Comstock, Geo. C. A Text-Book of Field Astronomy for Engineers. Wiley. $2.50.

D. Gillespie, W. M. A Treatise on Surveying. Two vols. Appleton. $5.00.

D. Hayford, J. F. Text-Book of Geodetic Astronomy. Wiley. $3.00.

C. Hodgman, F. Manual of Land Surveying. Hodgman. $2.50.

D. Johnson, J. B. Theory and Practice of Surveying. Wiley. $4.00.

Designed for the use of surveyors and engineers generally.

D. Ketchum, Milo S. The Design of Steel Mill Buildings, and the Calculation of Stresses in Framed Structures. Engineering News Pub. Co. $4.00.

D. Merriman, M. Elements of Precise Surveying. Wiley. $2.50.

D. Merriman and Jacoby. A Text-Book on Roofs and Bridges. Four vols. Wiley. $2.50 per volume.

D. Nugent, P. G. Plane Surveying. Wiley. $3.50.

Text- and reference-book for use of students in engineering and for engineers generally.

D. Patton, W. M. A Practical Treatise on Foundations. Wiley. $5.00.

D, C. Pence, W. D., and Ketchum, M. S. Surveying Manual—A Manual of Field and Office Methods for the Use of Students in Surveying. Engineering News. $2.00.

D. Prelini, Chas. Tunneling. Van Nostrand. $3.00.

D. Raymond, W. G. Plane Surveying. American Book Co. $3.00.

D. Root, E. A. Military Topography and Sketching. Hudson-Kimberly Pub. Co. $2.50.

D. Waddell, J. A. L. De Pontibus: A Pocket Book for Bridge Engineers. Wiley. $3.00.

C, D. Wait, J. C. Engineering and Architectural Jurisprudence. Wiley. $6.00.

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C, D. Baker, M. N. Municipal Engineering and Sanitation. Macmillan Co. $1.25.

C, D. Carpenter, R. C. Heating and Ventilating Buildings. Wiley. $4.00.

B, D. Chapin, Chas. V. Municipal Sanitation in the United States. Providence. $5.00.

D. Elliott, C. G. Engineering for Land Drainage. Wiley. $1.50.

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A selected reprint from descriptive articles from the "Engineering Record."

D. Folwell, A. P. Sewerage. Wiley. $3.00.

B. Frankland, Mrs. Percy. Bacteria in Daily Life. Longmans. $1.75.

D. Fuertes, J. H. Water and Public Health. Wiley. $1.50.

The relative purity of water from different sources.

B. Gerhard, W. P. Sanitary Engineering. $1.25.

B, C. Goodhue, W. F. Municipal Improvements. Wiley. $1.75.

C. Lawler, James J. Modern Plumbing, Steam and Hot Water Heating.

D. Merriman, M. Elements of Sanitary Engineering. Wiley. $2.00.

A manual of the methods, utility and cost of public improvements for the municipal officer.

B, C. Price, G. M. Hand-Book of Sanitation. Wiley. $1.50.

B, C. Richards, E. H., and Woodman, A. G. Air, Water and Food from a Sanitary Standpoint. Wiley. $2.00.

B, C, D. Sedgwick, W. T. Principles of Sanitary Science and the Public Health. Macmillan. $3.00.

C, D. Turneaure, F. E., and Russell, H. L. Public Water Supplies: Requirements, Resources and the Construction of Works. With a chapter on Pumping Machinery by D. W. Mead. Wiley. $5.00.

Roads and Pavements.

D. Aitken, T. Road Making and Maintenance. London. $6.00.

A practical treatise for engineers, surveyors and others. A historical sketch of ancient and modern practice.

D. Baker, I. O. A Treatise on Roads and Pavements. Wiley. $5.00.

Recent, quite complete.

C, D. Byrne, A. T. Highway Construction. Wiley. $5.00.

Treatise on location, construction or maintenance of roads, streets and pavements.

D. Codrington, T. Maintenance of Macadamized Roads. $3.00.

English, best in its line.

B, C. Gillette, H. P. Economics of Road Construction. Engineering News Pub. Co. $1.00.

C, D. Judson, Wm. P. City roads and Pavements. Suited to cities of moderate size. Engineering News Pub. Co. $2.00.

C. Love, E. G. Pavements and Roads; Their Construction and Maintenance. McGraw Pub. Co. $5.00.

C, D. Rockwell, A. C. Roads and Pavements in France. Wiley. $1.25.

C. Shaler, N. S. American Highways. $1.50.

C, D. Spalding, F. P. Roads and Pavements. Wiley. $2.00.

C. Stone, R. New Roads and Road Laws in United States. $1.00.

C, D. Tillson, George W. Street Pavements and Paving Materials. Wiley. $4.00.

RAILROADS.

C, D. Adams, B. B. The Block System of Signalling on American Railroads. Railroad Gazette Publishing Co. $2.00.

Describes methods and appliances; the best book on the subject.

D. Allen, C. F. Railroad Curves and Earthwork. $2.00.

D. Berg, W. G. Buildings and Structures of American Railways. Wiley. $5.00.

A good reference book on the subject.

C. Blackall, R. H. Air-Brake Catechism. Engineering News Pub. Co. $1.50.

A complete treatise on air-brake and signalling apparatus.

C, D. Camp, W. M. Notes on Track. Railway and Engineering Review. $3.75.

A comprehensive work.

B, C. Clark, T. C., and others. American Railway: Its Construction and Development, Management and Appliances. Scribner. $3.00.

B, C. Forney, M. N. Catechism of the Locomotive. R. R. Gazette. $3.50.

The simplest and most complete description of the construction and working of the locomotive engine.

D. Godwin, H. C. Railroad Engineers' Fieldbook and Explorers' Guide. Wiley. $2.50.

For use on locating and exploring surveys.

D. Goss, W. F. M. Locomotive Sparks. Wiley. $2.00.

C, D. Hall, W. E. Car Lubrication. Wiley. $1.00.

D. Henderson, G. R. Locomotive Operation. Railway Age. $3.50.

A modern and comprehensive treatment of the principles underlying the action of a locomotive.

D. Langdon. Applications of Electricity to Railroad Working. $5.00.

B, C. McShane. Locomotive up to Date. Griffin. $2.50.

A good book for engineers, firemen and those having to do with construction and repairs.

C. Meyer, J. G. A. Modern Locomotive Construction. Wiley. $10.00.

C, D. Modern Locomotives. R. R. Gazette Pub. Co. $7.00.

Contains drawings and specifications of 375 types of steam and electric locomotives and air motors.

B, C, D. Panghorn, J. G. The World's Railway. Angus Sinclair Co. $7.50.

A complete history of the development of railroad track and equipment.

C, D. Pettigrew, U. F., and Ravenshear, A. F. A Manual of Locomotive Engineering. Lippincott. $6.00.

C. Reagen, H. C. Locomotives: Simple, Compound and Electric. Wiley. $2.50.

D. Searles, W. H. Field Engineering. Wiley. $3.00.

A handbook of the theory and practice of railway surveying, location, and construction.

B, C. Sinclair, A. Locomotive Engine Running and Management. Wiley. $2.00.

D. Tratman, E. E. Railway Track and Track Work. Engineering News Pub. Co. $3.00.

D. Voss, Wm. Railway Car Construction. Van Arsdale.

D. Wellington, A. M. Economic Theory of Railway Location. Engineering News Pub. Co. $5.00.

A standard of reference and an analysis of the conditions controlling the laying out of railways to effect the most judicious expenditure of capital.

ARCHITECTURE.

D. Berg, L. de C. Safe Building. Two vols. Macmillan. $10.00.

Intended for architects and engineers, containing construction, formulas for strength, and numerous worked examples.

C, D. Birkmire, W. H. Architectural Iron and Steel, and Its Applications in the Construction of Buildings. Wiley. $3.50.

A little old now, but contains much valuable information.

C, D. Birkmire, W. H. Compound Riveted Girders. Wiley. $2.00.

Most practical book on their design and details.

C. Birkmire, W. H. Planning and Construction of High Office Buildings. Wiley. $3.50.

An excellent work on steel frame structures and the different methods of fire-proofing them.

D. Birkmire, W. H. Skeleton Structures. Wiley. $3.00.

An early book on steel frame buildings; of some value still.

B, C, D. Briggs, W. R. Modern American School Buildings. Wiley. $4.00.

A good general work on large school buildings, and their ventilation and warming.

C, D. Buhlmann, J. Architecture of Classic Antiquity. Germany. $18.00.

With English text. A fine collection of architectural motives taken from Grecian, Roman and Renaissance architecture; very valuable to architects, draftsmen, and students.

C, D. Building Trades' Pocket Book. Flexible morocco. Colliery Engineer. $1.50.

An excellent work for architects and builders, up-to-date, published in connection with the text-books of the International Correspondence School.

B, C, D. Carpenter, R. C. Warming and Ventilation of Buildings. A manual for heating engineers and architects. Wiley. $4.00.

Best general treatise on the subject, valuable for general reading by owners and for specialists. Good text-book.

B, C. Clark, T. M. Architect, Builder and Owner before the Law. $3.00.

A general statement of the principles of law applicable to the erection of buildings, intended to keep the laymen out of difficulties.

B, C, D. Clark, T. M. Building Superintendence. Revised edition. Macmillan. $3.00.

Good book for owners, architects, and superintendents of the construction of buildings.

B, C, D. Cumming, C. A. History of Architecture in Italy. Houghton, Mifflin Co. Two vols. $7.50.

Best history of the development of Christian architecture in Italy from its beginning to the opening of the Renaissance period. Fully illustrated.

B, C, D. Fletcher, B. F. History of Architecture. Fourth edition. London. $4.40.

The best text-book for serious students of architecture and readers, architects, and advanced amateurs and travelers. 240 plates of photos and details; very concise treatment; rather dry for general readers.

D. Freitag, J. K. Architectural Engineering. Wiley. $3.50.

A very complete and thorough treatment of the construction and fire-proofing of steel frame office buildings.

D. Freitag, J. K. Fire-Proofing of Steel Buildings. Wiley. $2.50.

A good work on different systems of fire-proofing buildings.

B, C. Hamlin, A. D. F. History of Architecture. Longmans. $2.00.

B, C. Holt, R. B. Rugs, Oriental and Occidental, Antique and Modern. A book for ready reference. McClurg. $3.50.

Description and colored plates of rugs from different countries. Descriptive circular sent on request.

D. Ketchum, Milo S. The Design of Steel Mill Buildings and the Calculation of Stresses in Framed Structures. Engineering News Pub. Co. $4.00.

D. Kidder, F. E. Architects' and Builders' Pocket Book. Flexible morocco. Wiley. $5.00.

Largest architects' pocket book.

C, D. Kidder, F. E. Carpentry. Comstock. $4.00.

Comprises carpentry and joinery of buildings.

B, C, D. Kidder, F. E. Churches and Chapels. Comstock. $3.00.

Best practical work on the planning and arrangement of churches, with Sunday-school rooms, etc. Many examples.

C, D. Kidder, F. E. Masonry and Metal Construction. Comstock. $4.00.

A good work on these subjects, for study and reference.

B, C. Litchfield, F. History of Furniture. From the earliest to the present time. $5.00.

A good and fully illustrated popular history of furniture.

B, C. Marquand, A., and Frothingham, A. L. History of Sculpture. Longmans. $1.50.

B, C, D. Moore, C. H. Development and Character of Gothic Architecture. Macmillan. $4.50.

Best description of Gothic architecture and its principles for general and professional readers. Good illustrations.

B, C. Mumford, J. K. Oriental Rugs. $7.50.

Many colored plates and good descriptions of oriental rugs from various places of manufacture. This and Holt's Rugs are of especial interest to ladies.

B, C, D. Sturgis, R. Dictionary of Architecture and Building. Three vols. Macmillan. $18.00.

A new, fully illustrated and valuable dictionary for reference, and also containing many valuable and extended articles for the use of the amateur and professional.

Other dictionaries and cyclopaedias are out of date, mostly foreign, etc.

B. Sturgis, R. European Architecture. Macmillan. $4.00.

An interesting history for general readers, with many good illustrations.

B, C. Van Dyke. J. C. History of Painting. Longmans. $1.50.

Rather brief, but an excellent general work, for general readers, ladies' clubs, art classes, etc.

B, C, D. Wheelwright, E. M. School Architecture. $5.00.

Best general treatise on planning and treatment of large school buildings. Author had much experience as city architect of Boston.

BIOGRAPHY.

Abernathy, J. S. Life and Work of J. Abernathy. London. Net $2.65.

American Engineering Competition. Being a series of articles resulting from an investigation made by "The Times," London. $1.00.

Church, W. C. Life of John Ericsson. Two vols. $6.00.

Glazebrook, R. T. James Clerk Maxwell and Modern Physics. $1.25.

Holmes, F. M. Engineers and their Triumphs. Net $0.60.

How, Lewis. James B. Eads. Net $0.65.

Hubert, P. G. Inventors (Men of Achievement). $1.50.

Judson, I. F. Cyrus W. Field, Life and Work. $2.00.

MacKay, T. Life of Sir John Fowler. Net $5.60.

Smiles, S. Industrial Biography. London. Net $1.25.

Smiles, S. Life of George and Robert Stephenson. London. Net $2.65.

Smiles, S. James Nysmith; an Autobiography. $1.50.

Smith, G. B. Life and Enterprises of de Lesseps. Net $2.65.

Stuart, C. B. Lives and Works of Civil and Military Engineers of America. $5.00.

Thompson, S. P. Faraday, Life and Work. $1.25.

Thorpe, T. E. Humphrey Davy, Poet and Philosopher. $1.25.

Trowbridge, J. Samuel F. B. Morse. Beacon Biographies. Net $0.75.

Telford and Brindley; Their Lives and Engineering Triumphs. London. Net $0.40.

DISCUSSION.

PROFESSOR VAN ORNUM: I note that the classification adopted involves what appears to me to be an unfortunate implication. I refer to the fact that under the class of books listed under "Civil Engineering" is grouped works on the two subjects of "Surveying" and "Structural Engineering," while such subjects as "Municipal and Sanitary Engineering," "Roads and Pavements," "Railroads," "Hydraulic Engineering," and "Materials" are given an independent classification, although these subjects are either altogether or in considerable part really civil engineering in essence, and very important branches of it. The important feature would seem to be that this classification by implication robs civil engineering of the larger part of its legitimate field. In other words it would give the implied approval of our society to such a popular error as we sometimes encounter, viz.: that surveying and civil engineering are practically synonymous. I note that similar ambiguity is avoided in mechanical and electrical engineering subjects by making the sub-classification, but omitting the general terms just mentioned.

I would suggest to the committee and society the advisability of avoiding such a situation by definitely placing the sub-classes of civil engineering under this general heading; or, perhaps better, inasmuch as it would more nearly harmonize with the general arrangement, by omitting the headings "Civil Engineering" and classifying the books given in the preliminary report under this head under "Surveying" and "Structural Engineering."

PROFESSOR D. C. JACKSON: I have little to say except in admiration for the work of this report. I would suggest the addition of four books, "Alternating Current Phenomena" and "Elements of Electrical Engineering" by Steinmetz, "Dynamo Electric Machinery" by Thompson, and "The Art of Illumination" by Bell.

MR. W. O. WILEY: The book on "Roads and Pavements in France" by A. C. Rockwell, and Dawson's "Engineering and Electric Traction Pocket Book" are now out of print.

MR. BASSETT JONES, JR.: A little magazine just started entitled "The Illuminating Engineer," and devoted to the science of illumination, is an excellent periodical.

PROFESSOR NORRIS: Along the line of electrical engineering literature I would say that our department in Sibley College has recently conducted a canvass of professors of electrical engineering and some practising engineers regarding the best books in the various branches of electrical engineering. The results of the canvass are as printed on the accompanying circular. I do not know that this is a model list, but it represents the concensus of opinion of a large number of electrical engineers. The first title in each group is presumably that of the work which gives the best survey of the subject; while the mastery of the entire list in any group should render a student entirely familiar with current practice as far as such familiarity can be acquired from books.

Electrical Engineering Department, Sibley College: Reference Books for Electrical Engineers.

The following list of books has been selected in conference with the leading teachers of Electrical Engineering and with a number of prominent practising engineers. Each book represents the judgment of a number of persons and the list is arranged in order of the number of votes cast. The list has been condensed so as to include only those books which are deemed most useful to a young engineer leaving a technical school. Suggestions for changes in this list will be welcome at any time, as it is proposed to issue it annually for the benefit of each senior class.

Electric Lighting.

"Electric Lighting," F. B. Crocker, two volumes, $6.00.

"The Art of Illumination," Louis Bell, $2.50.

Electric Railways.

"Electric Railways," Ashe & Keiley, net $2.50.

"Electric Railway Economics," W. C. Gotshall, $2.00.

"Power Distribution for Electric Railways," Louis Bell, $2.00.

"Practical Electric Railway Handbook," A. B. Herrick, net $3.00.

"Engineering Preliminaries for Interurban Electric Railways," E. Gonzenbach, $1.00.

"Report of the Electric Railway Test Commission,"* net $6.00.

Telephony.

"Telephony," A. V. Abbott, six volumes, $6.00.

"American Telephone Practice," K. B. Miller, $4.00.

Power Generation and Transmission.

"Electric Power Transmission," Louis Bell, net $4.00.

"Electric Transmission of Energy," A. V. Abbott, net $5.00.

"Storage Battery Engineering," Lamar Lyndon, net $3.00.

"Electrical Conductors," F. A. C. Perrine, net $3.50.

"High Tension Power Transmission, A. I. E. E. and International Electrical Congress Papers," two volumes, net $5.00.

Design and Construction of Electrical Machinery.

"Design of Dynamos," S. P. Thompson, net $3.50.

"Electric Motors," H. M. Hobart, $5.00.

"Induction Motors," B. A. Behrend, $1.50.

"Alternating Currents," Alfred Hay, net $2.50.

"Practical Calculations of Dynamo Machines," A. E. Wiener, $3.00.

"Armature Windings of Direct Current Dynamos," E. Arnold, $2.00.

"Induction Motors," B. de la Tour, translated by C. O. Mailloux, $2.50.

Measurements.

"Testing of Electro-Magnetic Machinery," Swenson and Frankenfield, net $3.00.

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* As this report is just off the press it was not included in the lists sent in, but it is mentioned here because it contains much experimental data.

"Electrical Engineering Measuring Instruments," G. D. A. Parr, net $3.50.

"Electrical Instruments," Carhart and Patterson, net $2.00.

General Practical Works.

"Electrical Engineers' Pocketbook," H. A. Foster, $5.00.

"Mechanical Engineers' Pocketbook," Wm. Kent, $5.00.

"Standard Polyphase Apparatus and Systems," M. A. Oudin, $3.00.

"Mechanical Engineers' Reference-Book," H. H. Suplee, net, indexed, $5.50, not indexed, $5.00.

"Steam Power Plants," H. C. Meyer, net $2.00.

"Practical Management of Dynamos and Motors," Crocker and Wheeler, $1.00.

"Laboratory and Factory Tests in Electrical Engineering," Sever and Townsend, net $2.50.

"Electrical Engineering," E. Rosenberg, net $1.50.

"Central Electrical Stations," C. H. Wordingham, net $7.50.

General Theoretical Works.

"Theoretical Elements of Electrical Engineering," C. P. Steinmetz, $2.50.

"Alternating Current Phenomena," C. P. Steinmetz, $4.50.

"Alternating Currents," Bedell and Crehore, $2.50.

"Alternating Current Engineering," E. B. Raymond, net $2.50.

"Elementary Lessons in Electricity and Magnetism," S. P. Thompson, net $1.40.

"Cyclopedia of Applied Electricity," American School of Correspondence.

"Dynamo Electric Machinery," S. P. Thompson, $7.50.

"Elementary Book on Electricity and Magnetism," D. C. and J. P. Jackson, net $1.40.

The most valuable reference books are the volumes of transactions of the engineering societies. It is suggested that students in electrical engineering join the A. I. E. E. either as students or associates. The value of the engineering periodicals should not be overlooked.

Professor H. P. Talbot: I notice that in the report on technical books for libraries there is no general work which seems to cover modern chemistry, including the applications of physical chemistry. I should like to suggest the inclusion of a book recently published by the Century Co. and entitled "An Outline of Inorganic Chemistry." The author is Professor Alexander Smith, of the University of Chicago.

Professor Magruder: I would suggest that the committee include the number and date of the last edition of each book. I notice that old editions are given, or described, where more recent editions have been published. The titles of a number of helpful older books might be added. The titles of quite a number of recently published books have been omitted. The number of books on mining engineering might be easily and wisely increased.

I would like to know the reason for limiting the number of titles to five hundred rather than to six hundred or more. Would the committee decline to publish the titles of new books, or would they feel forced to eliminate as many titles as they added? Why should some books be listed twice, and others be omitted? For ease in finding the general subjects, would it not be well to rearrange the latter so that they shall appear alphabetically in the table of contents? Why include the proceedings or transactions of certain societies, and omit the Transactions of the American Institute of Mining Engineers; also why leave out the Proceedings of a society called the Society for the Promotion of Engineering Education? Why include the Pocket-Books of Kent, Kidder, Suplee and Trautwine, and omit Foster's Electrical Engineers' Pocket-Book? Should not Wait's Engineering and Architectural Jurisprudence be included under "Reference Books," rather than under "Civil Engineering"? I would suggest the insertion of "The American Gas Light Journal," "The Gas Engine," a monthly magazine published in Cincinnati, and now in its ninth year, and "The Technology Quarterly," and that the bulletins published by certain of the engineering colleges be included.

I do not like to see Professor Kent's "Mechanical Engineers' Pocket-Book" designated as "the mechanical engineers' bible." The unintended irreverence, the slur on the profession, and the suggestion that this pocket-book is a "sacred book" are hardly in good taste.

The committee has done a laborious and useful piece of work, and should receive the thankful appreciation of the members of our society and of many others who will use the report.

PROFESSOR SWAIN: I would suggest that "Architectural Engineering" should be separated from "Architecture."

PROFESSOOR A. N. TALBOT: Some of the books on electrical railways are given under "Railways," and some under "Electric Power Transmission." Would it not be better to group all these under "Electric Railways?"

A MEMBER: I think that it would be well to have a uniform treatment of the books; to either give a full treatment, or none at all, in all cases. It is unfair to give one book ten lines, and another zero lines. There are numerous omissions in what the committee has called "Civil Engineering," and several other books on that subject itself should be included. I think that the list of books on "Railroads" is inadequate.

PROFESSOR D. C. JACKSON: I think that some of this discussion arises from a misapprehension of the purpose of the committee. The object was to make a list of books which could be used by librarians of to-day. Undoubtedly it has faults, but it is the best list of its kind yet made up. It is not supposed to be a list of text-books *per se*, but a list of books desirable for public libraries. I know that the committee have done a great deal of work and taken a great deal of time to prepare the report.

PROFESSOR KETCHUM: I agree very heartily with Professor D. C. Jackson in regard to the report and am willing to agree that it is the best report ever published, but I think that it is unwise to add to the report indefinitely.

PROFESSOR MAGRUDER: I had in mind what has just been said when I made my remarks. As this report is being very generally used by librarians and publishers, it should be up-to-date. Suppose one who knows little or nothing about engineering desires to present a book to a friend, or to add a book to a library, or to read up on some subject. He finds in this report a book on the subject by Mr. A., but some one suggests that there is another and a later book on the same subject by Mr. B. Not finding it in the list, he naturally decides that the judges who constitute our committee are of the opinion that the latter is too inferior a book to mention. And, even if it is mentioned, and without the number and year of the last edition, he may be led to choose a book published ten years ago in preference to a more recent publication.

PROFESSOR FORD: In reply to the question concerning the summary of the contents which appears after some of the books, I will call attention to the fact that in the first report of the committee few of the books were given any more notice than the author, title, publisher and price. When this report was reprinted by A. C. McClurg & Co. they added the publishers' announcements for many of the books. When the list of electrical books was revised, this practice was followed in cases where such announcements were at hand, so it is quite accidental what books are favored with extended notice and what are not. No attempt was made to add such notices to books already in the list.

PROFESSOR TYLER: I would like to ask if representatives of the American Library Association have been consulted by members of our committee?

PROFESSOR C. F. ALLEN: My impression is that Professor Burgess has been in consultation with the American Library Association. I remember he gave a paper at a meeting of the Association. In relation to the list of books, which is intended to cover general subjects, it seems to me that certain books might very well be among those omitted, since they are of a highly specialized nature. The selection of books for such a report must be a matter of judgment. I appreciate the work which Professor Burgess has done.

PROFESSOR A. N. TALBOT: I wish to ask why the Proceedings of the American Society of Civil Engineers are specified instead of the Transactions of the Society? The latter includes the revised papers and the complete discussion, while the former is in the nature of advance copies and is subject to correction.

PROFESSOR KETCHUM: The report was originally intended for general libraries. We have had applications from many libraries, but I do not believe that it has been used as an authoritative list for technical schools. The new list will be used as a complete list of technical books.

PROFESSOR SWAIN: It seems to me that we all appreciate the work of the committee, for the report certainly does contain a large amount of valuable information.

PROFESSOR BURGESS: It is highly gratifying to the committee that its report received the attention and discussion which the members of this society have given it. The remarks which partake of the nature of adverse criticism are no less gratifying to the committee than are the occasional words of commendation. The very nature of the work which has been undertaken, namely the passing of judgment upon the valuation for a particular purpose of a large number of books, allows many errors of judgment to creep in. It is naturally the desire of the committee to eliminate these errors as rapidly as may be, and suggestions as to the addition of other titles, such as have been made by Professors Jackson, Van Ornum, Talbot, Magruder, and others, will be gladly considered by the committee in the next edition of the list.

In the earlier work of the committee comparatively little interest was shown on the part of authors and publishers in the work which was undertaken. Members of the American Library Association, while expressing interest in the work, made no definite offer of assistance, except as individuals, although, as Professor Allen stated, the chairman of the committee presented a paper at a meeting of this association several years ago in which an outline of the proposed work was given and assistance invited. It is perhaps true that the committee should make effort to secure active co-operation, especially in the matter of revision of the list as to dates, editions, publishers, and the like, which will increase the utility from the librarian's standpoint.

Notwithstanding this lack of interest just referred to, abundant incentive for further effort was found in the cordial reception given to the first published list by librarians and by individual users of it. McClurg & Company of Chicago, with the approval of the committee and of officers of the society, undertook to edit the list and to give it wide circulation. Two editions have been gotten out by the company and thousands of copies have been furnished by them to book users in all parts of this country and abroad. The revision which the list underwent at the hands of this company consisted in the elimination of many errors of dates, prices, and editions, and removal of certain books which were no longer on sale. Some improvement in classification was effected, and, following out the suggestions of Professor Van Ornum, other improvements in this matter are shown to be capable of achievement. There is perhaps one criticism which may be urged against the revised list as published by A. C. McClurg & Company in their omission of the name of the publisher following each title. On the whole your committee feels that our society has been benefited by the revision and distribution of the list by this company, especially since they give due credit to the society for the work which it has done.

Following the wide circulation and extensive use of the list has more recently come that interest which was lacking at the start, namely its recognition by publishers and authors. This interest should be fostered still further since it urges upon the attention of the committee certain works which might otherwise be overlooked or which might not be given due consideration. This interest, while perhaps tending to increase the labors of the committee, will tend toward a greater efficiency.

The writer acknowledges the justification of the criticism that the idea of commenting upon each of the various books has not been satisfactorily carried out. The length of comment is in no wise a criterion to the value of the book and, as has been suggested, some of the more important books are listed without any comment whatever. Professor Magruder has pointed out an objectionable designation as far as one particular book is concerned and there are undoubtedly other objectionable statements. The committee feels that along this line alone there is abundant opportunity for further work.

The original purpose of the committee was to prepare a list suitable for the smaller libraries, this being recognized as the place where the greatest benefit from the list would be derived. We are brought to the realization of the fact that the scope of the work might be enlarged, that the list should be made suitable not only to the smaller libraries but to larger ones as well, not only to the general reader but to the technical man, not only to the general public but to those communities in which specialized industrial activity prevails, and where the demand for specialized trade and industrial literature exists.

We therefore see a large field for further effort and are brought to the realization of the fact that the work thus far done may be considered only as a beginning of work which this society or some other organization should prosecute in the future.

REPORT OF COMMITTEE ON STATISTICS OF ENGINEERING EDUCATION.

BY WM. T. MAGRUDER,

Chairman of the Committee.

In the report of your committee at the eleventh annual meeting it was stated (page 258, Vol. XI) that "your committee is now engaged in tabulating the seventy odd different degrees which have been conferred since 1824, in the ten subdivisions of the profession, and hopes to be able to present the tables as part of its next report." We regret to say that that "next report" is not yet ready.

In the report just referred to, it was asked that "if any of the members have lists of degrees which have been granted by their alma mater, or by the institution with which they are now connected, they will please send copies to the chairman." Possibly, the reason why that "next report" is not yet ready is because the chairman has not received copies of the "lists of degrees" as asked for.

The committee respectfully submits an earnest of its intentions in the form of a tabulation of the "Degrees Conferred by Engineering Colleges in 1904," as taken from the reports which have been received.

Referring to the same, it will be learned that of the 85 different kinds of engineering degrees offered for conferral in 1904, 22 were offered for post-graduate work and 68 were for undergraduate work, or a total of 90 degrees offered for work of different kinds and grades. Of the 22 kinds of degrees offered for post-graduate work, only 12 of them were conferred. Of the 68 degrees offered for undergraduate work, only 47 of them were conferred. It would seem as though the variety was almost 50 per cent. in excess of the demand.

Of the post-graduate degrees conferred, 28 of them were in civil engineering, 19 were in electrical engineering, 20 were in mechanical engineering, 3 were in mining engineering, 1 was in architecture, and there were 11 master's and three doctor's degrees in general engineering, or a total of 85 post-graduate degrees.

Of the baccalaureate degrees conferred, 613 of them were in civil engineering, 4 were in sanitary engineering, 395 were in electrical engineering, 615 were in mechanical engineering, 3 were in marine engineering, 28 were in mechanical engineering and electrical engineering combined, 228 were in mining engineering, 3 were in metallurgy, 11 were in mining engineering and metallurgy combined, 2 were in chemistry and metallurgy combined, 4 were in ceramics, 14 were in chemical engineering, 37 were in engineering chemistry and applied chemistry, 22 were in architecture, 18 were in textile engineering, and 395 were in general engineering, or a total of 2,392 baccalaureate degrees, and a grand total of 2,477 engineering degrees of all kinds and grades conferred in 1904.

It is the desire of the committee that its original intention shall be fulfilled. From such a set of tables could be determined:

First, the number of different engineering degrees which have been conferred by each institution;

Second, the changes which have been made in the lists of degrees offered by the different institutions;

Third, something of the history of the rise and fall in popularity of the courses leading to the different degrees, as well as other items of interest.

The importance of the subject was recently shown when facts were requested upon which to base an opinion relative to changing the degrees now offered by the College of Engineering of the Ohio State University. One of the results of that request is the accompanying table, prepared by the department of civil engineering of that institution, from data collected by the chairman of your committee.

In conclusion, your committee earnestly asks for the assistance of each and every member of the society.

L. E. Reber,
A. N. Talbot,
H. W. Tyler,
C. L. Crandall,
M. S. Ketchum,
Wm. T. Magruder, *Chairman,*
Committee.

D BY

Bach. of Sci. in Elec. Eng.	Bach. of Sci. in Engineering.	Bach. of Arts in Mining Eng.	Irrigation Engineer.	Bach. Sci. in Gen. Sci.	Pract. Chemist.	Master of Mech. Arts.	Bach. of Sci. in Arch. Eng.	Bach. of Sci. in Ry. Eng.	Bach. of Sci. in Mun. and San. Eng.	Total.
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THE BENEFIT OF PHILOSOPHY TO THE ENGINEERING STUDENT.

BY BASSETT JONES, JR.,
Consulting Engineer.

The philosophy of education can hardly receive adequate treatment in the space of a short paper, but I believe it is a subject that does not have the attention it deserves, particularly, at the hands of technical men. You will observe, I think, that few of the papers that have been presented to this society do more than review or discuss particular methods in special branches of professional education. While this is fully within the aim of these gatherings, yet it seems right that a study of the object of education should be considered equally as important as a study of the subject of education.

My thesis is not an easy one to present to you. The very abstractness of the argument requires for its development what may sometimes appear as abstract language; but philosophy, like law, depends for a statement of its theses upon the use of unambiguous and exact technical phraseology. Probably you will disagree with my conclusions more often than you agree with them. But if what I have to say presents to you in any way a fresh point of view, then indeed my purpose will have been accomplished.

The ideas to be presented in this paper had their origin in an attempt to overcome a feeling that there was something distinctly lacking in my own education, and I have since become convinced that at no period of my education, which was according to the prevailing system, could this want have been supplied. The omission was so keenly felt that a solution of the difficulty was sought in self training with more or less satisfactory results, but unsatisfactory because in the time available but a small part of the work to be done could be encompassed, and this only in disconnected fragments.

I do not feel that an apology for referring here to my own experience is necessary. My appeal is to be for a closer study of the self, since of necessity it is only through the experience of the self that the larger experience of the world can be reached.

I had completed the curriculum offered; I then supposed I was fitted to accept and fulfill any duties which my new profession of engineering might present to me. Yet when I came to face the world independent of others and dependent on my own efforts, I soon realized that, far from being ended, my education had just begun. That I realized little of what lay before me, I believe was due to the fact that, generally speaking, my teachers knew as little about it as I.

According to the usual methods, I had been trained to observe and classify certain special orders of facts. I had been taught to argue more or less correctly from such facts as premises to certain special results, and to embody these results in concrete form. With this preparation I was to journey forth into the world and make it my home. As one looks back on this venture it seems indeed a forlorn hope. Of the world into which I had come I knew nothing, yet a knowledge of its relations to me and my work seemed essential to my success in life. Now, by success in life I do not mean success in money-making, nor do I mean success in a chosen profession. Both are very desirable I admit, but desirable only as means to an end —namely, to live.

Thus I argued. Here am I a self-conscious individual pitted against the world, and, to me, this world is mostly a chaos of conflicting aims and efforts. Life appears as a ceaseless and ruthless struggle for supremacy—an eternal battle between the weak and the strong, physically and mentally. This, it seems, is a fundamental law. How then am I to so conduct myself that I may become one of the fit? Am I to confine my efforts to my chosen profession? But this is impossible. My profession cannot be separated from the rest of the world and treated as an independent entity, for I observe that my work is inseparably linked to that of others, that my interests and other interests are, in reality, one and the same. Indeed, try as I will, every idea of mine can obtain but a partial fulfillment if studied only in the light of what I have learned, and I observe that this is true, not only of professions but of every field of human endeavor and thought. Not a single fact but has its being bound up with the being of the world as a whole. No present experience that does not require all past and future experience to properly develop its meaning. Thus my argument brought me to an understanding of that true unity of human effort that is the foundation of all that is either good or wise.

Now these are indubitable facts that any one who attempts to grasp even a single aspect of the world must accept and apply. Thus observed, the world loses all of its sinister character. Strife, hatred and immorality are seen in their true light as the outcome of ignorance. The real struggle of the world is to gain a harmony of purpose. This struggle is due to a continuous development towards ideality—not the idle perfection of the mystic ideal—but a life that can give the fullest expression to the best of which our race is capable.

It was in failing to teach me the basic principles of life that my education was amiss. I was given a tool, but knew nothing of the nature of the material with which I was to work. And this, it seems to me, is an essential defect to be found in all present systems of technical education.

It is idle to object that a knowledge of life can only be gained by experience. It would be equally true to say the same of engineering. If it is necessary that we should be educated to fit us for the duties of a profession, it is, at least, equally important that we should receive an education that will fit us for the duties of life. The first makes a machine of the student. The second makes him a living being.

Nor can you object that this training for life is the object and duty of the home schooling, for I accept your objection, but I add this, that the home is the proper school for life only when life is there studied, not after the usual haphazard methods, but as a subject worthy of careful analysis and scientific treatment. Life in our world has become so complicated and withal so little understood, that a man needs more than hereditary instinct and the influence of a too often biased and prejudiced attitude to guide him aright. Whether good or evil is to be predominant in his life is purely a matter of whether he has been so trained that he can foresee what deeds of his will bring his life into harmony with the life about him, and whether he has the strength of will to abide by what his judgment teaches him is right. But the transition from thought to deed must not be made on insufficient or false reasoning. The experience of each of us is quite a different thing from the experience of our parents or of our teachers. What seems right to the individual in the light of his parents' ideas may be quite wrong and immoral for his own life. He must be taught to think about and correctly analyze his *own* experience. He must, so to speak, take the world into his confidence. It is the expression of his own individuality and he must make the best of it.

We may say then, with the Émile, that the art of living is the trade we are to teach, and whatever else an education may do for us, if it is to make us worthy of our opportunities, it must first show us how to live. How we ought to conduct ourselves toward the world is then the essential point, and before we can intelligently outline a scheme of conduct we must if possible learn what relations the finite self bears to the world at large.

The world, says the philosopher, is your larger self. It is "the totality of life that at this moment you fragmentarily grasp."* In short, the world is purely what you make it. A narrow life means a narrow world. It is the full life of a full world that you must seek to live. This is your task and anything short of complete success therein leaves you a bankrupt in proportion to your failure.

But, to live completely, you must put yourself in touch with all the world, not with one small aspect of its being. The men who have outlined the world for us, the men whose wills are expressed in our life—

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* "The World and the Individual," Royce.

the consistent selves and individuals of our finite world—were never men of narrow lives. Life and the world meant more to them than the interests of a single self or of any one group of selves. They grasped the whole unity of the world, its all-embracing purpose, and its manifoldness in unity as expressed in our separate but closely inter-related selves. Our lives have been moulded by such men of deep understanding and, by them, our thoughts have been turned away from the merely possible to an expression embodied in the valid and the concrete.

In fact no one but the man of broad knowledge knows or realizes the depth of the intricate connections and interweaving among the many fields of human effort nor can hope to guide this effort so as to prevent the clash and confusion arising through mutual ignorance. We sometimes say these men have great executive ability which is only another way of saying that their deeper insight enables them to see farther than ourselves. They are able to say to the specialist, "Your efforts will be quite useless unless carried on in this or that direction." Why? Because, from their viewpoint of the world, they stand above the specialist. Because their scope is larger; because for their practical purposes the world is a many sided object, each facet formed with a purpose expressed in certain laws, and the whole presenting one governing principle that they more or less completely grasp.

I do not say that such men are always the highest type of the individual. But they illustrate the principle that the man whose systematized knowledge is the broadest is best equipped to meet the demands of whatever he conceives his life to be. The true life of the world is infinitely beyond any such hard work-a-day expression because the best life must be founded on an essentially moral basis.

We often hear it said that this is the age of the specialist. That every man must devote his entire time and all of his efforts to one thing, that he is only valuable in so far as he knows more than any one else about some one subject. Success is possible to such a man, if by success one means that he is to be the slave of his business, and that, when all is said and done, he leaves only his business behind him. Does he ever stop to ask himself what it is that he is so ardently striving to do? You may say that the love of gain is not generally the actuating principle. It is, you claim, the love of work, and the joy of achievement that serve as motives to spur him on. Yes, but spur him on to what? How can he know that his efforts are not relatively wasted if he does not know what it is that he is to gain by his struggles for self-expression? Is it fame? But, what an etheric will-o'-the-wisp is fame! So weak is its flame that it is fairly extinguished as death snatches the laurel wreath from the lifeless brow. Is it achievement? Lo, even as the mason lays the stone it crumbles in decay. Is it discovery? Wider knowledge, like the sun, causes your torch to cast its shadow. Is it wealth? Verily, death shall find you poorer than the beggar. So the story runs. The passing things of this moment—in what consists their stability and worth? And all that our empirical sciences call life—has it no such deep foundation of truth that its purposes and being can find no better expression than in things such that, even as we grasp them they are torn from our faltering hands? Is it that such things are but the surface ebullition of the current boiling beneath? Such we claim they are, and we also argue that their only value is the indication which they furnish of a life absolute and individual in itself, yet embracing an infinite variety of modes of expression of which our life is but a fragment and, mayhap, nay with every probability, a very insignificant fragment at that. Even so we are not doomed to disappointment. In eternity all purposes must be fulfilled—indeed their fulfillment is an implication of their being just as every part of the winning of that fulfillment, even this part taking place in our temporal world, is a necessary and integral portion of the fulfillment itself. But, all finite effort makes for a successful culmination only when that effort is in harmony with the deepest purposes of life, and is therefore moral. Temporary success may seemingly be achieved where immoral deeds are the outcome of discordant purposes, but the toll is rigidly exacted in every case and all the world must eventually pay for every transgression of the moral law. Such is our outcome. The principle that ought to guide our lives is the principle of harmony, and its deepest meaning cannot be found in any fragment of the world, but only through experience, knowledge, and appreciation of what the world in its totality can show us.

So that the specialist so-called simply leaves out of his life the greater part of that experience the winning of which ought to constitute his life-work. He gains no self expression. His individuality has no scope and though he may count himself successful, his success is of a very illusory nature. He may win fame in his own field of endeavor. His work may produce great results. He may make great discoveries. He may count great wealth as his. But surely success is not found only in such passing things. Other men who in their lives have achieved none of these have still counted themselves successful. Is it then to win happiness that should be the summit of ambition? But happiness is a very relative term. Our really great men have rarely been happy men. Rather is happiness the outcome of ignorance. We are happy because we know no better.

The only criterion of success then is the value of the finite individual life as a moral agent. We should strive, not for our own ends, but for universal ends. Your life is successful just so far as it helps to unify and harmonize experience, and this is a task that can never be temporally accomplished. Those who set themselves a duty whose fulfillment can be won in the period of our human time span can only meet with disappointment, and this is a necessary corollary of our finitude. Whatever deeds are the outcome of my purpose in this finite life ought to be looked upon only as stages in the development of the internal meaning of my ideas. What I must seek is a clearer determination of my will and I can never find just what it is that I ought to do unless I first determine what relations my life bears to the world about me. Therefore, the chief purpose of my education should be to give me such an understanding of the rest of the world that I can at least in some way properly see my own life as contrasted therewith. That this is an endless task I admit, but at least the developing self can be made to understand where he is to find the world and how he ought to interpret its relations to himself.

In whatever way the lesson is learned the process is the process of philosophy, and my thesis is, that the best way to teach the student to philosophize is to teach him philosophy. My thesis of course applies to every branch of education. But I claim that it has special force when studied with science, because science itself is our method of keeping the books of our experience of nature.

You may say that the work of the specialist certainly is a great harmonizing force. He is following one thread of experience and he is compelled to so mould his life that his deeds harmonize with the deeds of those about him. In this you would be quite right. But my point is this—that it is not so much what we do but what we are that is the principal criterion by which we should be judged. In specializing with the elementary student you deliberately cut him adrift from most of life, and it is only later and through the hard lesson of adversity that he gains even a little of that broadness of conception that makes him of any value to the world.

Suppose, if you will, that specializing is the wisest method of teaching a profession. Suppose this fact accepted, and that each one of us is a specialist in some one branch of experience—that is, each one of us is so trained that only a single narrow field of related facts is open for each one's investigation. Where then would lie the common meeting ground? How could we interchange ideas and study one another's deeds? Surely you will not deny that such a common base is essential to our very being. I can safely say that unless there is the possibility of such a thought exchange, the world would be but an intellectual chaos, and, further, the more extended our understanding of the work of other selves the more complete must be our own individual effort. Indeed, if specializing is the best way of living, then what can the future hold out for us save the life still narrower; the individual contracted within limits where the self is completely lost. With each step one more link that binds idea to idea, one more of the self-knots, is undone; individuality loses its meaning; the world becomes like the dried leaves of the forest, driven hither and thither by every gust that blows, because no community of plan, no central interest binds all together into one harmonious whole. Yet it is at the same time true that a man should by all the means in his power seek to do well whatever he undertakes. His ambition should be to make himself a leader, the first in his profession. But he must not make himself lopsided or he will defeat his own ends.

Does it not seem that specializing has reached or has nearly reached the end of its evolution? It has served its purpose, but like all processes in the world, it must complete its cycle. Other intellectual forces are at work and in turn a new school of progress must arise. We begin to realize that at a certain point the specialist loses control. Finally the last binding link is severed and his work, no longer governed by ties to the rest of life, loses its restraint and so its usefulness. It will, of course, be said that specializing is the outcome of the law of survival; that it is the world at large and not the individual whose ends are to be served and that concentrated individual effort gives best expression to the progress of the world. Well, if by progress you mean that a man shall become the machine for the expression of one idea, if the world is to have no meaning for each save as the field for the exploitation of his pet hobby, if all that so called "common sense" calls unpractical is to be sneered down as useless rubbish clogging the wheels of this great engine of life, if poetry is to die out among us and the spiritual and intellectual be voted a bore, "if all uncultivated plants are to be classed as weeds, then indeed is it useless for men to learn anything that does not directly help to replenish the till and fill the larder."* But if the pleasures of life are of any moment, if altruism still is a force among men, if nature means more than a vast physical laboratory, in short, if there is any use in living, then by all means let us first try to live aright, let us start our young people out in life with at least some training in those two most useful acquisitions of the mind, imagination and an appreciation of the beautiful. You adequately train the imagination in certain lines, but there you leave it. The beautiful or sense of proportion which is the kernel and blood of life you criminally neglect.

Now I hope I shall not be accused of dogmatism. Nothing so horrifies the philosopher as a dogmatic attitude. I merely wish to give you in as brief a form as my available time demands an outline of what modern philosophy has to say of the world. I do not ask you to accept what I say without giving the matter due thought. A fact is true for reason or else it is not true, and this is as true in philosophy as in the special sciences. The world is done with axioms. For my authority I appeal to yourselves. In physics as in mathematics we are no longer satisfied with assumptions. We no longer begin an investigation with an if.

Yet in spite of this, I am told that I must formulate my life *as if* this or that assumption is true. I am asked, what bearing has philosophy on practical living? Why do you burden your mind with subjects of such general and universal character? I answer, what can have more obvious significance for the life of each of us than the study of the meaning of the world and of our place within it?

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* "Education," Herbert Spencer.

It is hardly necessary to say that unless the fulfillment of a conscious purpose is made evident through the life of the world, the world itself can have no meaning. For the world is nothing unless it is the consistent outcome of our ideas about it, and ideas only obtain their expression through the purpose of a will to get its meaning concretely embodied. The life of the world is then intimately bound up with the life of the self, and only as the self comes to require more of the world as the expression of its will does it rise in the scale of being. Thus the world and the individual must rise and fall together. There is no other alternative. A man and the world are both the better for his being, only as his life requires more of the world for its expression, but his life must be in harmony with what we may perhaps call the world-life, the *totum semul,* or one inclusive individual life. Only as this harmony exists is the life of the finite self moral, and only as it is moral does it help and not hinder the progress of the world.

I am afraid all this is in too metaphysical a strain, but it is necessary to show that life is not a subject to approach in any haphazard manner and that its meaning and a study of its purposes are worthy of the most thorough attention. You would hardly entrust the design of a complicated and delicate piece of machinery to a novice. You would require the designer to be thoroughly conversant with the laws governing its construction, the principles employed in its operation, and the purpose for which it is intended. Yet how few of our young men are sent forth into the world well trained in the chief business that is to employ their efforts; namely the business of living. Do you think that the learning of any one profession is a sufficient preparation for life, or is likely to give us the power to give the greatest amount of good to the world? Is it not strange that even a few so trained are passably successful, that as the dusk draws near perhaps one man in a thousand—yes, thousands!—can look backward with a light heart and say, "My life has not been a failure, but has brought me happiness, comfort and riches unmeasured in gold. I have found life worth living, and whether or not my works are soon lost to the memory of man, yet have I done the chief thing that a man can do in this world. I have lived."

"To live in the broadest sense of the word; to live completely, that is the great thing that education has to teach";* and failing in this, education is itself a failure.

You should seek to train the student to so bear himself to the world that the world shall enter fully into his being, and shall make of him no narrow professional, but a man of broad parts who can seize upon and claim for his own all the best thoughts and best works of those men who have made the world a place in which to live. To give the student a broad knowledge of fundamental principles and the logic of organized thought so that he can at least attempt to cope with any environment in which he may find himself placed—this should be the chief aim of technical education.

* "Education," Herbert Spencer.

It is nonsensical to plead that in a short four-year course no more than a very special training can be acquired. You have no right to assume, as you do, that all the student needs to fit him for life is a course in studies mapped out for him in advance by men who know nothing of his special intellectual ability. The "average student" bogey has about been worn out by overwork and as a result we find in our workshops and laboratories numbers of men who have either been trained too little or else trained too much. How frequently we see the man and the opportunity come together only to fall foul of each other. The man has been trained in one special field and is out of his depths the moment he crosses its borders. His sense of proportion is so ill-developed that he fails to observe that the process of thinking is the same all the world over and in all mental activities of which finite mortals are capable. Too late he realizes that all the possible experience, considered in the light of his narrow little world that he had avoided as unconsequential in reality had very deep and close connections with his own life.

The student comes to you determined to become, let us say, an electrical engineer. He is fresh from the high school and full of the hopes and imaginative ambitions of youth. He has not the faintest conception of what he is about to undertake as his life work save such amusement and occupation it has furnished for his boyish ingenuity. Of the rest of the world he is absolutely ignorant.

You take him thus in the most plastic years of his life and with no attempt to make him aware that the world is other than he has fancied it to be, you plunge him into a course of special studies that leaves him saturated with the idea that he has become something apart like a machine that can turn out but one particular article. Now this man may find as many another has found to his cost, that his opportunities come in a very different field than the one that he in his deep (?) wisdom has selected for himself. Or he may find too late, as others have done, that had he but realized his talents he might have made a better success of himself in an entirely different line.

I am not preaching a sermon of discontent. I am no pessimist. But I do believe that until a man has gained some knowledge and experience of the world, he is but ill-fitted to determine what life relations he and the world should bear to each other. The first essential in his education is broadness. He must be given a perspective in which he can see things in their right connections with one another and with himself. Then only is he able to judge his opportunities. He then sees them in several ways at once and can intelligently grasp their true magnitude.

Such a training of course takes time. But is it not worthy of all the time it demands? Surely the responsibilities of the engineer are no less than those of the lawyer or of the physician, yet in both these fields the student is required to show good reason why he should be permitted either to learn or to practice his profession.

I do not doubt you will say that this interest in many and often widely separated subjects will tend to give the student a diffused attitude of mind. Unless he possesses great powers of concentration he will find himself very apt to merely skim over a train of thought or else jump from idea to idea without carrying any one thing to a conclusion. I fully appreciate the danger of this "scatter-brained" type of thinking, but usually its seriousness is due to the fact that while the student is given a vast field for the employment of his thoughts he is given no guide that will serve to direct his ideas in one way rather than another, or that will suggest to him relations between topics that the practical mind considers widely sundered.

The only training capable of furnishing the influence that will bind all the student's ideas together and will color all his thoughts with one exclusive interest is the training of philosophy. Philosophy will individuate the whole world for him, precisely as electrical theory will individuate for him the whole field of electrical engineering, or as mechanics will individuate for him the whole field of mechanical engineering. It will enable him to conceive and order his world in a perfectly logical way.

It has often been put forward as an argument that life is too short and the demands of our age too strenuous to permit a man to do justice to himself in more than a very narrow field of endeavor. On the other hand, it seems to me a question whether he does himself any but the most tardy kind of justice under these conditions, and whether the conditions that make such demands apparently necessary are either beneficial or moral. Does not this very narrowness of training and life only serve in the end to refute its own arguments? When we find that specializing induces a wide interest in the duties of society; when charity, humility, honesty and love find a growing interest in each one's heart, then and then only may we say that man lives.

And where, you ask, are we to find an adequate concept of life to which the student may turn in his dilemma? The answer is plain. Wise men have, in the compass of their short lives, given to the world systematized accounts of the experience of their age. We call these men philosophers, and often laugh at them and at what we self-styled practical men are pleased to call their dreams. Yet, even though in our ignorance we fail to realize it, these same men have given to us all that we possess. Their work is not an attempt to explain the mysteries of the world, but merely to give a reasonable account of what in the past our attitude to the world has been and a critical analysis of the implications of life. No more, no less, you see, than the efforts of the empirical scientist in his narrower field. .

And we all of us philosophize more or less; indeed we must, otherwise we could not hope to guide ourselves aright. But if we are to live aright our philosophy must be, for our own lives, a true philosophy, and in this as in everything else we must be trained to think.

Now I do not suggest philosophy as a general panacea. You can hardly fail to appreciate however that it will give to the student a method of analyzing his own thoughts and feelings in a way that at least ought to help him to a better view of life and will serve him as a guide in living. He will learn that in life as in everything else all depends upon the way in which you view your own experience, and this in itself is the very view you are attempting to make him take of his profession.

Philosophy does not put itself forward as a substitute for the special sciences, but rather as their complement. It does not determine the realm in which empirical investigation should be conducted, nor does it attempt to state hypotheses by which the order of empirical facts should be described. What philosophy does is to show us how we ought to proceed in estimating and interpreting the world as science finds it.

I have time only to suggest the benefit of philosophy as developing the true scientific attitude. Much deeper and fuller than mathematics, which expresses in skeleton form the bare outline of a system of critical thought, philosophy talks to us of the flesh and blood of our being. Indeed, in recent years philosophy has encroached upon all fields of learning and has lent to science its power as a tool of investigation. It is the parent of all exact knowledge and as such is worthy of your careful consideration.

To one who has not learned to critically analyze his own experience and to contrast it with the experience of others it often seems the height of folly to question the being of the world in its positive aspect, but we must remember that truth is purely relative and that what we know is real only in the light of experience and not absolutely. Our experience is only the shadow of truth. It continually leads beyond itself and is never complete. A very brief study of the thought of past ages will make this evident, and we shall find ourselves skeptical as to the truth of all that we now so confidently hail as unquestioned fact; but skepticism and doubt have always been the goads that drive men into new pastures, and wider fields of knowledge.

It is easy to laugh at the metaphysician. One asks, what good does all this logic-chopping? Why should we not take the world as we find it and cease this endless questioning as to the exact nature of things? Because we really do not find the world at all. Because the world comes to us only as sentience and apart from sentience it has no reality. Not that what is real is not a true other to our ideas about it, but it is only a true other in as much as it is the consistent outcome of these very ideas. So that when you say that you find truth or that you succeed in doing what you with purpose have determined upon, what you imply is, that your ideas develop themselves consistently and without internal contradiction. You may will to do many things the actual doing of which is beyond you just because if executed they would prove to be outside of this, your world, and not a consistent development of your life, but you may by a careful study of just the conditions that surround you and make your life just what it is, in some measure, at least, overcome the breach between your finite experience and the absolute experience which we seek to find in reality. In this way alone can you gain an understanding of the world that will enable you to find the best possible expression for your life. But reality is not to be found as the outcome of any one set of finite ideas, but as the complete fulfillment of all ideas that can produce a harmonious whole of experience.

This world of fulfilled purpose taken in its totality is present, at any instant, to our consciousness as what the psychologist calls the "felt background." That we acknowledge such a whole of feeling is clear, but in our every day life we are concerned chiefly in discerning what the structure of this whole world is other than the facts that now occupy our attention. All science is busy with this question. In its attempts to describe this world science employs the process of observing facts between which it seeks to find still other facts which will form the bonding links required by thought, and that will unify the empirical world for us so that we shall find in it a more or less complete expression of our life-purpose. But we must remember that, as we thus discriminate between those facts that fulfill our present purpose and the rest of the world, what we find possesses no finality. We must not allow the apparent fixedness of the laws of nature to form the ground for the assertion that the world has any fixed structure to which science is the key. For reality is not the physical world apart from the conscious knowledge of this world, and any attempted description of reality that fails to acknowledge both the fact and the knowledge of the fact is never more than half the truth. The choice of a specialty in this endless work of description is purely a matter of personal taste, and "because of our human narrowness," says Professor Royce, "any one man has to confine himself to his specialty." Each is to find his facts. He is to look for the invariant characters that are common to each of these observed facts and also to the linkage of implied facts that serve to transform one fact into the other. In stating the nature of these invariants, the observer states a law which we say governs the facts observed.

I do not wish to be understood as disagreeing with Professor Royce as to the narrowness of the specialist's field. I merely observe that this narrowness is unfortunate because it tends to blind the specialist to this very narrowness. His tendency is to observe facts in a very one-sided way. He does not look all around them as he should. I agree that the specialist has to confine himself to his chosen field, but he must not forget that his field is as limitless as the world itself; and he must realize that the invariants in any transformation of facts may be quite different for different aspects of the facts themselves. To use a concrete example, the railroad engineer, if he is to be successful, must learn to look at his special problem not only as a problem in engineering, but also as a problem in transportation, a problem in finance and a problem in sociology; to mention only a few aspects of the facts between which he is to establish an interpolated series of related facts. Each view may cry for a separate solution, when he must be broad minded enough to weigh each solution properly. In fact his attitude to life is the fundamental thing. He must be free from bias. That he is an engineer must not overweigh the fact that he is also a student of traffic problems, a student of economics, and a student of the growth, distribution, and classes of population.

And we find this true not only in this one example but also in every means of gaining a livelihood that we can suggest. The best man is always the broadest man. And this explains why in Europe the men who stand out as leaders of great enterprises are generally engineers. In America it is the engineer who does the bidding of the man who has founded his technical knowledge on a broad general education as a basis.

Now all this seems quite evident from the standpoint of common sense. Surely no one questions that life is more than an eternal adjustment of conditions, yet there is no doubt that life also in a great measure makes just these conditions. The whole subject then sums itself into the following: No man can make the best of himself unless he knows and understands what

he himself means. His life is not something apart by itself. It is a fragment of a whole, but a fragment that is itself bound to every part of the whole. If the Life of the World is something different from the individual life then it matters not in the least what the individual does. His act cannot effect the final result. Such a world can be immoral with impunity, and can be the abode only of the fatalist. But if the acts of any one finite individual react in any way, for good or for evil upon the lives of his fellows, then it is vitally important that he should learn how to conduct himself wisely, not only as regards his own life and interests but also with reference to the world at large. The basic feature of every education then ought to be a study of the principles which experience shows us underlying the structure of the conscious world.

DISCUSSION.

PROFESSOR LANDRETH: This paper comprises a rare and almost new type in the literature of the promotion of engineering education. In the main and in the light of the striking but unfortunate over-specialization into which many of our engineering schools have drifted, the recommendations of the writer are timely and in the right direction. They might with almost equal propriety be extended to other subjects than philosophy.

Looked at from the standpoint of the needs of a learned profession of wide scope and still wider future possibilities, the engineering training given at present in many of our schools is clearly deficient in breadth of general culture and narrow even in technical lines. Two causes are responsible for this result: (1) The shortness of the course of study, being rarely more than four years, and (2) the unwise effort to crowd into this time much training which is purely special in the futile effort to make efficient specialists without first preparing a broad foundation on which to build. Four years after high school is too short a time in which to complete the education of a man and the training of an engineer and the portion of time allotted to the engineering training is all needed for thorough foundation work in the fundamentals of the profession, and being too short at best for this important work should not be encroached upon for specialization. The welfare of the engineering profession, and therefore of society which it serves, would be better subserved by turning out men of broader and deeper fundamental preparation in both general and technical directions, even though, at the time of graduation, they possessed less special training and were less immediately useful as assistants. The author makes a strong appeal for the study of philosophy for engineers, but his paper is more than this; in reality it is largely a plea for the study of the humanities in general. Many of the arguments advanced would be equally strong in support of the importance of history, literature, æsthetics, sociology and economics, all of which are desirable if not essential to the training which every well-educated engineer should acquire. The "trade of living" is not learned from philosophy alone.

The recognition of the importance of this broader training in the engineer's preparation is a matter first to claim consideration and must precede any effort to provide for it. In the endeavor to provide for such broader training it does not appear desirable to increase the requirements for admission beyond those now laid down for our best engineering schools, as these are already up to the limit of the average preparatory schools of high grade. Provision for such broader training appears feasible therefore only in two ways; either (1) by increasing the length of a course of study in engineering schools to five or six years; or (2) by reducing the amount of time now given to specialized study of narrow engineering topics.

This problem has received considerable attention at Union College and a course of study is now under consideration which by extending over six years will include virtually all of the classical college course without Greek and all of the general engineering course without much specialization. The work of the two courses has been carefully correlated and the studies of both interwoven together throughout the six years in such manner as best develop the man and the engineer together. If finally adopted* this course will not replace the present four-year engineering courses, but will be alternative to them and young men who are able to devote six years to their general and professional education, which is not more than is now given for similar training in law, theology or medicine, will, it is believed, secure a much better assimilated training than if the engineering course were given after the completion of the college course.

In such a course the study of philosophy and the humanities in general, selected and taught with special reference to the training of the citizen-engineer, finds adequate provision.

Mr. B. Jones, Jr.: As I said in my paper, to live at all we must philosophize and guide ourselves by our philosophy. To make our philosophy for our own lives a true philosophy, we must be trained to think logically. But the life of each one of us is not a separate entity—it is a part of a fuller life that is inclusive of all life. The philosopher studies our individual lives as contrasted with this inclusive life, and so seeks to find the laws of conduct which should govern our activities.

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* Subsequent to the date of this discussion, the above course was officially adopted by the faculty of the Union College Engineering School.

The question is then, how are we to give our students this perspective view of life. Are we to leave them to find their own rule-of-thumb ethics? Do you not realize that much of your dissatisfaction with your own life, that many of your own failures are due simply to the fact that you were never given any means to logically gage your purposes and so your deeds? It is just such a gage as this that philosophy furnishes, and for this reason I believe that in any school of any kind philosophy should be made an integral part of the curriculum. I do not refer to the cut and dried philosophy of the text-books. I mean the general philosophic attitude—to teach engineering not as merely a recurrent application of certain empirical rules of experience, but as a means of embodying our purposes, and a critical examination of these purposes—how they arise, what influences mould them, and so, whether they are good or evil.

We should begin then very early with the training of the young mind in the path of reason. The student should receive a very careful training in the analysis of first principles and their relations to thoughts and ideas—as the modern child is taught arithmetic—not by a mere sing-song recurrent rote, but by first seeing that the expression of the self takes the general form of the well-ordered series and that the fundamental category of the human mind is the category of order.

I have spoken of the philosophic attitude in teaching. Let me illustrate what I mean. Numbers of the older graduates from Sibley College have told me that one most valuable part of their course was the course of lectures on geodesy delivered by the lamented Professor Fuertes and this was so not because the lectures of Professor Fuertes dealt ably with the subject of geodesy. They were usually not lectures on geodesy at all. They were talks on the philosophy of living.

I am not a professional teacher, and I do not know what is the best way to give the student this philosophic training. I only feel its lack, not only in my own case, but also in the case of the great majority of technical graduates with whom I have had opportunity to talk. I believe that the student should be taught something of the nature of the principal tool he has to use—namely his mind. Psychology and logic are as important to the engineer as physics and mathematics.

Professor Waldo: How many good engineers would have been spoiled by waiting for them to get their A.B. degrees before entering upon their technical training?

Mr. B. Jones, Jr.: I do not believe that we would spoil any good engineers, but we would prevent a good many bad ones from getting into practice.

Professor Caldwell: I am a great believer in the general training of an engineer and think that there is much to be looked for in this combination of the arts course with engineering. We must have specialists, but, especially where there is no essential reason for hurrying a man through, it is always wise to broaden out, and to get more than a strictly technical training. It seems to me that the combining of the courses, as is often done with law schools, can be very well extended to the engineering colleges. We have, however, one difficult problem to deal with, namely, the bringing of the students to appreciate this point of view. I remember that four years ago one of our engineering professors was very much pleased to have persuaded a promising young man to start in the arts course with the expectation of later taking one of the engineering courses. I was, therefore, interested to learn recently that this student, having finished his arts course, was now going immediately into practical work.

PROFESSOR MARVIN: This leads to a rather fundamental thing, and I think that what has been said would be applicable to much of the work that has been done in our colleges as well as to work in the technical schools. It is a matter of more specialists, and I have come into contact with plenty of people in sympathy with it. Now it seems to me that we must take conditions just as we find them. It is well enough to think of the ideal man, but those of us who are connected with state institutions know that we must take the material that comes to us as graduates of high schools and train it, as best we know how, in order that we may get the best results; so that it is a matter of more education for the great majority rather than an education for gifted people. I think that we ought to have means for doing this, but we cannot do that and gain the most. Now I think that there are some things that can be done in a school with a four year's technical course without the necessity of putting in courses in philosophy. I perfectly well agree with the suggestion that has been made that the personality of the teacher has more to do with a student's outlook on life, more to do with his breadth of view, than anything else. I know one man, an experienced teacher, who will stop a recitation suddenly, without premeditation, however, in the resistance of materials for example, and go off into a discussion of ethics, matters of taste or other desirable things that a man should know about, which are not found in a scheme of study, but which have much to do with a young man's outlook on his future life. The digression is stimulating to the men and its spontaneity gives it force and effect. It even stimulates effort along technical lines.

MR. B. JONES, JR.: I cannot agree with one of the speakers that the processes of evolution are continuous after the nature of the continuity of a straight line. Evolution is the name for the general type of change processes that we find common to both organic and inorganic worlds. These processes are always cyclic changes having a very general recurrent form. There is development to a certain critical point after which there is a general re-arrangement of the factors involved followed by a further change often in a very different direction. Such critical points we meet in the melting point of ice and the boiling point of water; in the sudden rearrangement of the corpuscles in the atom as developed in recent experiments on the nature of matter and as illustrated by Professor Mayer's experiments with floating magnets; in birth and death; and in Professor de Vries' experiments on mutation in plants; Darwin's own work on evolution furnishing another point in question.

I am not prepared to say that we have arrived at such a critical point in the development of educational systems, but I certainly think that the relatively sudden and deep interest that has been recently shown in the subject points to the near approach of such a point.

THE JUSTIFICATION OF THE USE OF THE EXPRESSION "ENGINEERING MATHEMATICS."

BY ARTHUR E. HAYNES,

Professor of Engineering Mathematics, University of Minnesota.

I am constrained to write briefly on the above topic because, so far as I am aware, the expression "Engineering Mathematics" originated in the University of Minnesota in January, 1901, when the writer, with the approval of the president of the university, changed the name of the professorship he occupied from the professorship of mathematics in the college of engineering to the professorship of engineering mathematics.

The reasons for the use of this name are at least three.

First: Because of the main object of the study of mathematics in an engineering course. In a purely disciplinary or academic course, the objects of the study are, first, mental discipline and, second, its practical use. In a professional course, such as engineering, these two objects are reversed in relative importance, and the primary object in such a course is to so master the subject as to be able to make a correct and intelligent use of its principles and formulas in practice. In other words, these principles and formulas are to be used as "tools"* by which, like as the student uses a plane or any other tool of the shop, he may secure desired results.

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* I think that this expression was first used in this university. See Proceedings of the Society for the Promotion of Engineering Education, Vol. VIII., pp. 308–310. [This is questioned.—W. T. M.]

Incidentally, in mastering the logic involved, the student gets excellent mental discipline, but there is added to this a still greater discipline and a commendable inspiration in applying his knowledge so as to get direct practical results.

There is, to be sure, some valuable discipline in so studying a jack plane as to understand its construction completely, but one can do all this without being able to properly plane a board.

Just so one may, for instance, be able to develop a mathematical principle or formula without being able to use it intelligently in securing results.

Another example is ventured for illustration; in physics, where the members of the class are simply studying for the knowledge alone, and not for the object of applying such knowledge, they may completely understand the philosophy, for instance, of the sextant, and yet be perfectly helpless when required to find the angular distance between two objects by means of its use.

In fact, in the study of mathematics of an engineering course, the student must constantly challenge principles and formulas with the question what use has this in practical application to my chosen profession. In truth, three questions are constantly pressing upon both the student of engineering and the professional engineer for positive and definite answers; they are: What do I want? Do I know how to secure it? Do I know how to use it intelligently and correctly?

Suppose, for example, he finds it necessary to solve a problem in trigonometry, he may have to answer these questions repeatedly, as in determining the proper formulas, and in correctly selecting and applying them; again, in the same problem, the determining whether to use natural or logarithmic functions and the proper selection and correct use of them. And thus it comes about, in the study of mathematics for engineering purposes, that the main object sought fixes or shapes the method of study. But this leads naturally to another reason for the justification of the expression and that is:

Second: Because such an object requires a different kind of teaching. Some one has recently said: "In almost every branch of instruction there is a gap between theory and practice, between principle and application. In nothing is this more manifest than in the teaching of mathematics."

As has been already indicated, one may, by mastering a mathematical principle, secure valuable mental discipline; but if the teacher makes this the primary or chief object, he will not teach the subject with the success that he would have, by having constantly before him the thought that skill in the intelligent use of mathematics in practice is the main end to be attained.

And so the question may here be legitimately asked, will the teacher untrained in engineering practice or not educated as an engineer, be as likely to succeed in such teaching as one who is so trained or educated? I think this question must be, in general, answered in the negative.

Such teaching requires, on the part of the teacher, that he be able to intelligently direct the student in his study, that he have the ability and good judgment to select problems that shall wisely lead the student to a correct and practical application of his knowledge, and above all, that he possess the power of constantly inspiring the pupil by high ideals of work and of life.

But if the object sought shapes both the method of study and of the teaching of the subject, it leads directly and logically to still another reason for the justification of the expression, and so we have:

Third: Because the content or extent of the field covered is different. For example, long and abstruse discussions of principles and formulas are omitted, the object of which is mostly mental discipline and which have little or no direct practical value, while subjects not found in former treatises are added. A good illustration of this is seen in introducing the philosophy and use of the slide rule after the theory and use of ordinary logarithms have been properly considered. The student is thus led to the intelligent comprehension and use of one of the most valuable aids in modern engineering practice.

Again, after a study of the theory of ordinary integration, the study and use of the polar planimeter, or mechanical integrator, adds great interest and value to the student's work.

In conclusion, it may be said that, in consequence of the three reasons given in this paper for the justification of the term "engineering mathematics," great and valuable changes have been made during the last decade in mathematical text-books for engineering students, and we may ultimately expect nothing further to be desired in such works.*

DISCUSSION.

MR. B. JONES, JR.: A great part of the trouble with our present methods of teaching mathematics lies in the way the subject is approached. I can never forget a remark once made by Professor Charles R. Cross to the effect that mathematics was nothing but common sense in shorthand. So it is. History will teach us that mathematics has been developed, not as an end in itself, but as a means to an end, namely to compress long exact arguments within such a scope that they can be readily grasped all at once within the time-span of the reader. The same end is attained in good writing where the author clearly states in one short sentence what the ordinary man could hardly express in half a page. The meaning of the sentence or of the formula is thus brought within the span of an instant of time and both its first and last word or sign are grasped at once.

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* I think the use of the terms Engineering Drawing, Engineering Physics, etc., is equally justifiable.—A. E. H.

We find mathematics primarily used to express briefly those factors in a process that are observed to remain constant throughout that process. A formula thus expresses the form of the invariants of a series of related facts. Hence, logically, the observation of the facts should come first and the formula follows. Two oppositely charged spheres do not follow the law of inverse squares. The law of inverse squares describes for the purpose at hand the behavior of the two oppositely charged spheres. Physics is to be taught not as a series of cases of the validity of certain formulas, but the formulas are to be found as adequately describing the conduct of nature.

PROFESSOR A. N. TALBOT: I have always been in favor of making a generous use of applications to engineering in teaching mathematics, not so much for the skill and facility in making applications which the student may acquire in this way, but because such applications for most students form a good means of giving a clear conception of mathematical ideas and processes which might otherwise be very hazy. The applications give life and meaning to seemingly abstruse mathematical statements. And yet in late years it has seemed to me that there is a tendency in this country to carry this to an extreme and for the student merely to learn how to apply rules or formulas which he assumes have already been established. Formal demonstrations and the philosophy of the work are likely to be disregarded. As the pendulum swings toward the practical side, it must not be forgotten that sound logic, formal demonstration, and mathematical form of statement are essential features in the solution of engineering problems and that the development which goes with a training along these lines should form an important element in the education of the engineering student.

PROFESSOR C. M. WOODWARD: I have always rather regretted the attempt to limit the range of mathematical study even in an engineering school. One never knows when mathematics will be of use. I believe that a comprehension of the meaning of mathematics is one of the fruits of good mathematical training. I think I stated that a certain college president regretted that mathematics was found so useful. He said that mathematics has been found so useful that its educational value has been greatly hampered. Now I thought that superb nonsense. I believe that the mastery of a subject is what makes it valuable and it cannot be thoroughly learned until you have seen that you are the master of it. And so I like to see the best kind of mathematics of service to the world at large.

PROFESSOR WALDO: Nothing can prevent the deduction of new terms. I should like to have in this paper a statement of how the term engineering mathematics comes. I do not know what engineering mathematics is and I do not see any difference between one kind of mathematics and other kind of mathematics.

PROFESSOR HENRY T. EDDY: I think that some of the great scope of mathematics has been directly suggested and stimulated by its applications. It is not unfair in our educational system that mathematics be connected with the reality. As all knowledge is essentially experience, and as everything new is that suggested to us by our own experience, or that of the race, I think that there is no real difference between pure mathematics and applied mathematics, although this distinction is frequently drawn. I love pure mathematics, but I think I love applied mathematics better.

PROFESSOR TYLER: I agree with Professor Eddy. While the term engineering is based on a good underlying idea, namely, mathematics, the adaptation of mathematical instruction to engineering uses, there is no more real reason for "engineering mathematics" as a distinct subject or title than for "engineering physics" or "engineering chemistry." The university president who Professor Woodward tells us deplored the increasing applications of mathematics was, I think, far from representing the attitude of our present day mathematicians. The use of such a title as "engineering mathematics" seems to me calculated to promote an unfortunate tendency which would leave the pure mathematics to the mathematicians and leave the applied mathematics to the engineers. The increasing utilization of mathematics is in this country the great hope of the science for the future, and should be welcomed by the mathematicians most cordially.

PROFESSOR WALDO: I think that possibly the idea which the author had in mind when he made the distinction between pure mathematics and engineering mathematics was that the latter is more thoroughly understood. If we investigate mathematical conditions prevailing in our institutions at about the seventies, we will discover that mathematics was the bugbear of the collegian to be memorized for the examination and forgotten as quickly as possible. Engineering schools have greatly changed these conditions. The person who does not wish to pursue a mathematical course takes what the academy requires of him and stops, but the person who is going to apply his mathematics seeks more in an intelligent way and in the end has something to show for his work. Of course in all of our institutions there will be a saving remnant who love mathematics and pursue it for its own sake, but their number is small; but all our great body of trained engineers must know and use a moderate amount of higher mathematics as a tool with which to serve mankind. It is their useful work that has rescued the pure mathematician from the derision of his fellows.

PROFESSOR SWAIN: I wish to emphasize one point which seems to me open to criticism, and that is the idea that there should be a different kind of teaching of mathematics in an engineering school from that which is suitable in colleges. It seems to me that there is only one way to teach mathematics. The main object of all teaching is to give the student some power of thought, some power to do something which he could not do before. I, therefore, think that there is just one way to teach mathematics, and that is the way that we try to teach it to engineering students so that they will be able to use it when they have learned it. Unfortunately, much teaching is not of that kind and gives no power. I do not agree with the idea that mathematics taught for general culture, so-called, should be taught any differently from teaching it with the use of it in view, and I hope that the idea of teaching mathematics, or anything else, for that matter, with its applications in view will come into use more and more. I think that the teacher of mathematics who has been trained as an engineer, or in some branch of applied science, so that he knows the uses of the tools he is teaching, will have a great advantage as a teacher, and achieve much better results than a man who, though he may be a fine mathematician, is an abstract one.

MR. B. JONES, JR.: During the last four or five years a course of lectures to journeyman electrical workers and operating steam engineers has been given at the New York Trade School. These lectures were primarily for men engaged in handling and erecting steam and electrical apparatus and who were anxious to better themselves. The fundamental idea at the basis of the course was to teach these men to think.

Generally the men who attended were bright and able. They only required to be showed "how," but like most men of their class they had an inordinate dread of theory and of mathematics. This was overcome very simply by showing by means of experiments that theory and formulas are no more than descriptions of fundamental physical facts. Thus the law of the magnetic circuit was taught by means of a coil of wire and a magnet, writing down on the blackboard a description of the experiment as it was performed. Then this description was simplified successively by representing certain whole sentences by letters, and eventually the proper formula replaced the entire writing. Thus the men learned that mathematics was a shorthand expression for a description of what they had observed in the experiment. That this system of teaching mathematics was effective was shown by the readiness with which problems requiring some little original thinking were worked out.

The method was, of course, not original with these lectures, as it is merely an extension of the modern method of teaching arithmetic and the elementary mathematics employed in our common schools.

While I am on the subject let me recount to you a story about one of the men attending this course. He is an assistant engineer in the works of the American Glucose Co. As I remember, his age is twenty-five. It was noticed that he always carried books about with him, and one day the instructor who had become greatly interested in the man's cleverness and bright questions, asked him what he was reading. It was a history of philosophy. The student stated that he had studied philosophy, logic, and psychology since he was eighteen years old, because, he said, "it gives one such an insight into things, makes one satisfied to live the best one can, and teaches me that the things worth doing are the things that can never be fully accomplished in this life."

He is indeed a man to be envied.

PROFESSOR C. F. ALLEN: I wish to say a word with reference to the statement that the engineering college is first an educational institution and second a trade school. I object to the idea that is conveyed to my mind by that statement and I would say that I believe the college is a distinctly educational institution. To my notion what the engineering college stands for is that theory cannot be properly taught except in connection with its applications. And it is from that standpoint almost exclusively, it seems to me, that the practical work of the engineering college is justified.

PROFESSOR NORRIS: My idea is that a technical school is properly an educational institution. Of course we have to devote more or less time to trade-school work, but our students come to learn a profession and not a trade. Teachers of engineering believe that we should, in teaching technology, have its educational value prominently before us.

PROFESSOR F. B. WILLIAMS: I think Professor Swain is correct and that we ought to begin early in mathematics and take time to teach it. There is danger in introducing the "rule of thumb," before men get out of college. They can learn these short methods after graduation. We should insist upon the students working things out logically with a clear understanding of the principles used, for they are too apt to try first one way and then another just to get the answer to a problem. The idea of "engineering mathematics" is a good one, but it involves a thorough teaching of mathematics. The teacher should have a thorough mathematical training and a thorough engineering training; and then when the theory is taken up and developed, he will be able to make a practical application of it.

PROFESSOR CRANDALL: In support of the idea that it is not necessary for the teacher of mathematics to have an engineering training, I would say that one of the very best teachers of mathematics to engineers that I know of is a man whose education was academic, and his degree was that of bachelor of arts.

Professor C. F. Allen: It seems to me that that paper proceeds on the assumption that our engineering colleges graduate engineers. I think that most of us believe that we graduate young men who have a good foundation for becoming engineers. To my mind, the paper proceeds on the basis that the engineering college does graduate essentially engineers, a thing which I do not believe in at all and I think most of us do not believe in.

REPORT OF THE COMMITTEE ON INDUSTRIAL EDUCATION.

BY CALVIN M. WOODWARD,

Chairman of the Committee.

The Committee on Industrial Education has no formal report to present at this time, but expects to make a formal report at the next meeting of the society. There is a very general discussion now going on in educational and industrial circles in regard to the establishment and operation of trade schools. A committee, of which the Hon. Carroll D. Wright was chairman, met during the summer of 1905 and discussed the whole question of industrial education in its relation to the mechanical trades. Although the committee met in Massachusetts, the discussion is not confined to New England, but has spread to the west. Your committee will have something to say about the matter at the next meeting of the society.

DISCUSSION.

PROFESSOR SWAIN: I should like to ask Professor Woodward for some information with reference to the work of the committee. It was my understanding that further work of the committee was postponed in order to await the publication of a report by the United States Commissioner of Education, giving the results of an investigation then in progress. I should like to inquire if that report has been completed or published, as it has not come to my attention.

PROFESSOR WOODWARD: By arrangement with the association, three addresses were presented. Our committee intends to present a report as soon as it has something good and new, but we do not care to publish just a few statistics. We desire to outline a scheme for the industrial education which is based on manual or elementary technical education. That is what we hope to present at the next meeting.

PROFESSOR TYLER: It may be of interest to the members of the society to know that the report of the recent Massachusetts Commission on Industrial Education, of which President Carroll D. Wright was chairman, deals very thoroughly with conditions in Massachusetts. The legislature has since taken steps in accordance with the recommendations of this report toward the working out of a comprehensive plan for industrial education.

PROFESSOR WALDO: Professor Thurston's last paper was published in our proceedings after his decease and related to different kinds of education. A careful reading of it would show that Professor Thurston was not entirely in harmony with some of the notions presented early in this session.

THE DUAL DEGREE FOR ENGINEERING COURSES.

BY PAUL C. NUGENT,
Professor of Civil Engineering, Syracuse University.

The College of Liberal Arts of Syracuse University graduates its best students according to their class standing during the four years of the college course, "cum laude," "magna cum laude" and "summa cum laude." Since the organization of the L. C. Smith College of Applied Science, its faculty has followed, in this matter, the example of the College of Liberal Arts. Lately, however, there has been some discussion as to the desirability of this plan when the students in question have pursued engineering courses. A committee having been appointed to investigate the matter, it was decided to correspond with a number of prominent engineering schools located in the same general section of the country, and to ascertain their customs and opinions on this subject.

A number of letters were thus received; and, while only one pronounced very strongly against the honor system, most of the schools have not adopted it, and the general trend of opinion seemed opposed to the plan.

The purpose of this "graduation with honors" is twofold; first to reward merit, and, second, to stimulate the student to more strenuous efforts to gain high standing in his class, and thus result in graduating a better class of men. In a measure it fulfills the first of these purposes. It is a satisfaction, and a justly deserved one, for the good student to have his work publicly recognized. It may be questioned, however, whether the second purpose is accomplished at all. For the honor men will almost always be those who, in the absence of the honor system, would still stand at the top of their classes. There are too many students, both in engineering and elsewhere, who are perfectly contented to graduate, and to these men the obtaining of honors, even if possible, offers very little incentive to more extensive and laborious effort. What can be done then during the college course to obtain better work, not from the best, but from the worst of our graduates. It may, of course, be assumed that all students *absolutely unfitted* to pursue a course in engineering have been dropped from the college rolls early in the course. Now there are in vogue in the schools of this country two systems of granting degrees in engineering work. Under the first system, on the satisfactory conclusion of the course, the student is granted the full engineering degree and may sign himself C.E., M.E., E.E., etc., as the case may be. Under the second system, the degree granted is that of Bachelor of Science in Engineering. The full engineering degree is given on the completion of say a year of post-graduate work, or perhaps two or three years of practical work and the presentation of a thesis.

This makes practically three systems. As among these three, the writer is strongly in favor of the first and very strongly opposed to the last. It is intended to suggest a fourth and entirely different plan. The advocates of the third system claim that the average graduate is not fitted to be called an engineer. The same objection applies to the granting of the M.D. degree on the completion of the medical course, or if it does not, it is because the medical teachers and courses are superior to those found in engineering schools, which we are entirely unwilling to admit. There is no reason why engineering cannot be taught just as practically and just as professionally as is medicine.

The objections to the third system are first, that it amounts practically to making the whole question a matter of quantity instead of quality. What we need is not to have our students learn more things but to learn things more. Compare for instance the cases of a graduate of high standing who for some reason does not follow the profession of engineering for the first few years after graduation and of his classmate who having barely graduated goes out, runs levels for three years, writes some sort of a thesis, and gets his full degree. In the second place, by what right can a school grant a degree for work done outside of its own supervision? How can it determine just what the kind and quality and amount of this work have been? In one case, the candidate may have done a large amount of high class work, and in another practically only routine duties. In the third place, considering the cases of two graduates, force of circumstances may throw work in the way of one while it deprives the other for a considerably longer time of the practical work demanded for the full degree. In these days of "graft" and "pull," the school should be one place where as far as may be possible the same opportunity is open to every man and where recognition follows merit just as sure as merit exists. If we think it best, before granting the full degree let us hold our students to one or more post-graduate years. But let that degree be given as the reward of work, open as far as possible to everyone, and done under the direct supervision of the school's officers of instruction.

The second plan has its origin in the same idea as has the third. Here we have again quantity vs. quality. The four years of the usual course are full enough in all conscience, but they are long enough to determine pretty thoroughly the stuff that is in a man. The student who has not in four years assimilated enough facts and learned to think and reason clearly enough to deserve the full degree, will not, in all probability, become so qualified at the end of another year. The average engineering course covers the ground pretty thoroughly in four years, and post-graduate work will probably consist mostly of special investigations. As far as the schools have anything to do with it, a man is an engineer when he has sufficient mental ability and sufficient familiarity with the theory and facts of his profession to practice it with a reasonable degree of intelligence and ease. Four years is long enough to accomplish this result. It is possible that the graduation, in the past, of a certain percentage of weak men has had its effect in inducing some schools to defer the full degree. These schools would possibly be willing to confer the full degree at once were their worst graduates of equal rank with their best.

The consideration of these facts has suggested to the writer a fourth plan. At the end of the regular four- or three-year course, let two degrees be granted; the B.S. being given to those who have passed in all required subjects but have failed to attain a certain set grade. This grade to take into account (in the case of four-year courses) all the work of the last three years. The required percentage, while reasonably high, should not be as high as that demanded for what is now known, particularly in Liberal Arts courses, as graduation with honor. This plan places the engineering degree where it should be—on a higher plane than that occupied by the baccalaureate. This is recognized by the schools which now consider the full degree as post-graduate.

The general details would have to be worked out, but it is believed by the writer that no other plan would so stimulate the activity of the lower half of a class. Many an engineering student who would not give a thought to graduating with honors would redouble his efforts when it came to the case of graduating as an *engineer*. This would especially be the case were the plan adopted among engineering schools generally. Another result would be that almost every *engineering* graduate would be a man to whom his school could point with confidence and pride. It might perhaps be desirable to hold the way open for the B.S. men to return for a year to obtain the full degree. But in such cases the dominant thought should be that of quality. The post-graduate work should deal not so much with the teaching of new things as with the better and more thorough teaching of the old. It should aim to produce, if possible, better reasoning powers and general ability in the student, and, failing that, the full degree should never be granted.

The writer does not know whether these ideas would be entirely satisfactory in practice, but is inclined to believe, on the whole, that they would. They are offered for the consideration of the society in the hope that a discussion will be had, which, whether or not favorable to this plan, will be of value to the cause of engineering education.

THE IMPROVEMENT OF THE FRESHMAN YEAR OF MATHEMATICAL INSTRUCTION IN TECHNICAL SCHOOLS.

BY CHAS. S. SLICHTER,

Professor of Applied Mathematics, University of Wisconsin, and
Consulting Engineer, U. S. Reclamation Service.

I shall consider this subject very briefly in two parts: first, the course of study; second, the instructional force.

I. *Reform of the Freshman Course in Mathematics.* —It is no mere accident that the movement for reform in elementary instruction in mathematics was coincident with the recent period of phenomenal growth in technical education in this country. The enormous expansion of the technical schools has exerted its influence in more than one way upon the development of pure science. It is no secret that the pick of our bright youth in this country has gone into technical courses of study during recent years to the detriment of other lines of intellectual work. Many of these men would have taken courses in pure science under conditions existing twenty years ago. The prosperous years for applied science have therefore not been contemporaneous with years of equal prosperity in pure science. Not only has the number of students of pure sciences remained nearly stationary, but the complaint is very general that the caliber of the men has materially fallen off. The brightest and most ambitious of our youth have been attracted to technical courses, and, to a less degree, to courses in history and economics, but not to the natural sciences. These facts, I am confident, account for the very general conversion of the teachers of mathematics in our higher institutions to the belief that the elementary instruction should be thoroughly improved and enriched. The great vigor with which the Perry movement has been pushed in England during these same years has made it easy to get aid and comfort for the American campaign, and to profit in many other directions of advance. It is significant that those in charge of the mathematical work in our technical schools have, as a class, been somewhat conservative in their attitude toward the new movement. They are too vitally interested in a strong and scientifically developed course of preparatory mathematics to desire to risk much by revolutionary changes, and they no doubt fear that the new movement has some danger of running wild as an educational fad, to the real detriment of proper foundational work in secondary mathematics. This country has little to learn, except by way of bad example, from technical instruction in Great Britain. It is probably a fact that real reform in secondary instruction in mathematics in this country had more to avoid than to simulate in the Perry movement.

Fortunately there is every indication that the changes that are being made in mathematical instruction in the American secondary schools are being planned with care and good judgment. The introduction of graphical methods and of mathematical work of a practical sort is becoming very general and in most instances is not being carried to extremes.

The reform movement has not been confined to the secondary schools. Some technical schools have made radical changes in the mathematical work of the college course. Those who have worked out the matter independently have arrived at very similar results. The changes consist for the most part of modifications that naturally follow from the movement in the secondary schools. The tendency is to blot out entirely the present lines of distinction between algebra, trigonometry and analytic geometry. These changes have involved, not only the early and constant use of graphical methods, and abundant use of numerical data, but have also included the early consideration and application of vector analysis, and a study of the theory of nomographs and similar subjects.

My own experience with the modified courses has been very encouraging. I have been delighted with the success of the students and of the instructors with every change that has been attempted. In fact the encouragement has been so great that I am convinced that the time is ripe for very extensive and radical modification of our first year's work in technical mathematics. I have had an opportunity to discuss this matter with the heads of mathematical departments in several of our technical schools and I have found general accord with the reform and little difference of opinion concerning the general character of the changes that should be made. There will be a great advantage if the changes in the courses can take place in a large number of institutions at the same time. For a number of years I have introduced a large amount of geometrical work in the course in higher algebra. In doing this I have tried to avoid what seems to me to be the greatest danger in this work, namely, the danger of falling into merely routine graphical work rather than work that is thoroughly scientific and that calls out at every point all that is in the student. I hand you herewith some samples of cross section paper which we had printed in order to aid in bringing out the possibilities of such work. The examples given on the cover page are merely suggestions of the work that the students do. We find it very easy to give the student a very thorough insight into the properties of the common functions by the use of this paper. The various plates are drawn to scale to fit an ordinary 10-inch C. E. rule, and the bond paper upon which the plates are printed permits many interesting combinations by superposing sheets before blueprinting.

I have been slow to break down completely the barriers between algebra, trigonometry, and analytic geometry, largely because of the difficulties that arise in adjusting the courses of the migrants that come to us from small colleges and other institutions. This difficulty would be partially met if the reform were taken up in a number of institutions at about the same time. Independent of the action of other institutions, we have reached the point at the University of Wisconsin where we shall entirely break down the barriers between the courses in higher algebra, trigonometry and analytic geometry. We shall convert these into a single course in analysis, with the various topics introduced at the proper and logical time and independent of the traditional order in which they now appear in the separate texts. Our most treasonable act is the deposing of the conic sections, which have been the reigning family for so many years, from their exalted place in our course of study. This gives an opportunity for the more abundant enrichment of the course and a better comprehension of those things which the student of applied science needs. Such a course not only conforms more nearly to the actual needs of the student, but it even has the advantage of being more logical and scientific than our old courses. As a matter of fact all that the engineering student learns in his usual course in mathematics is a simple comprehension of the properties of the algebraic function and of the circular and exponential functions of the real variable. Indeed we might define the work of the engineering student, during his two years of mathematics, as the study of the exponential functions of the real variable. Indeed we might define the work of the engineering student, during his two years of mathematics, as the study of the exponential and circular functions: in his first year he considers these functions in ordinary calculus; in his second year he considers them in infinitesimal calculus. He never gets beyond these elementary functions. The modification of the freshman course that we propose recognizes the logical unity of the material of study and is in fact more scientific than the system at present in vogue.

The danger in the new program lies in the possibility that the new work will be less strenuous and less scientifically complete than the usual courses in analysis. This can only be avoided by watchfulness on the part of those who plan the courses and by assistance and criticism of results on the part of the engineering departments that depend upon good mathematical preparation for their students.

II. *Instructional Force.*—When we come to consider the make-up of the instructional force we find the very greatest difference of opinion among those that are interested in the subject. Personally I hold to the opinion, which has been so well expressed in recent editorials in the ENGINEERING NEWS, that the instructional force teaching the mathematics to engineering students should be made up of men that have themselves taken a technical course. However, when we come to apply this principle under existing circumstances, we find the greatest difficulty in its practical application. In order to be competent to carry on instructional work of this kind, an engineering graduate should have had at least three years of graduate work in mathematics. Under existing conditions the graduates of technical schools are unwilling to give this amount of time to their preparation for instructional work. In fact, it is exceedingly difficult to attract any of the graduates of the technical schools to instructional work of any kind. The opportunities for a successful career in technical work have been so great that the appeal is almost entirely to the professional ambition of the young man. On this account it seems hopeless to secure technical graduates as instructors who have made adequate preparation in mathematics.

I have myself experimented to some extent with engineering graduates as instructors in mathematics, and I think I can say that the best work of teaching that I have ever had done has been by graduates of an engineering course. These men had very little preparation beyond the regular work of their course in engineering, but they were especially selected on account of their all around ability and their interest in scientific subjects. I find, however, that it is no easy matter to retain such men on the instructional force. As soon as good professional opportunities open before them they feel obliged to accept them, and under present conditions instructors who have taken the engineering course prove decidedly unsatisfactory on account of the temporary tenure of their office.

When we come to consider candidates for instructional work from the other class of students, namely, those who have made a specialty of the course in pure mathematics, and have taken their master's and doctor's degree, we find almost equally unsatisfactory conditions. In the first place there is a great dearth of active men in the graduate schools of mathematics at our large universities. Even those that take their major work in mathematics too generally neglect advanced laboratory work in physics, chemistry and other sciences, which should form an essential part of their work if they expect to prepare themselves to do adequate work as instructors in technical schools.

I had hoped that these conditions would show some change in the near future, so that we could attract a reasonable number of engineering graduates to advanced work in mathematics and later provide them with places as instructors in the technical schools. In order to aid in securing men of this kind I believe it would be a great advantage if the men who give instruction in mathematics could be given some work in the more technical part of the undergraduate course. I see no reason why a combination of this sort is not practicable. If an instructor, for example, could give two thirds of his time to the work in mathematics and the remainder to work in the hydraulic laboratory, or in the testing laboratory, or to instruction in mechanics or any other of the courses of this kind, he would feel that he had not cut himself off from technical work and from advancing in the engineering profession. A great many will undoubtedly believe that a proposition of this kind is too radical; that it is not practicable to make a division of labor in the way in which I have indicated, and that the tendency of the time is in favor of specialization and not in line with a proposal of this sort. To this I can only reply that outside of administrative difficulties I can see no reason why the work of the instructor cannot be thoroughly well done, even though a part of his time be spent in the laboratory. There is undoubtedly a danger that the principal interest of the instructor will be in the technical work and laboratory work, rather than in his mathematical instruction. I fear this less, however, if we require for this purpose students who have taken at least two years of graduate work in mathematics. In any case, it seems to me to be necessary to accept this as a fundamental requirement in the selection of the instructors.

I desire to say a few words concerning the conference system which we are trying to introduce at Wisconsin in the instructional work in mathematics for freshmen and sophomores. For the purpose of conferences with the students we have divided the instructional force for the current year into three groups. These men are present in the office of the department on Tuesdays and Thursdays from 4.00 to 5.30 P. M., and on Saturdays from 9.00 to 10.30 A. M. At these conference hours any students in any of the courses are at liberty to appear for any assistance or additional explanation of the classroom work that they may desire. In the instructions which I have given to the various members of the teaching force, I emphasized the need of not only inviting all of the students that so desire to attend the conferences, but also that students that are behind in their work, or doing poorly for any cause, shall be urged by the instructor to attend. I have also suggested that these invitations should not be confined to the weak students that need help, but should be extended to the brighter students as well, who might profit by encouragement and suggestions which would lead to more enthusiasm and better work on their part.

We have been very much pleased thus far with the success of the conference system. Each instructor keeps a diary or record of his work with the students. Another year we expect to develop the conference system still further. The work of the instructors in the conferences will hereafter be a principal consideration in determining their promotion. The campus at the University of Wisconsin is not adequately lighted in the evening at the present time, so that we are unable to put the conferences in the evening. As soon as provided with adequate light, we shall hold these conferences every evening from 7.00 to 9.00 o'clock, except Fridays and Saturdays, but shall undoubtedly continue our conference on Saturday morning. Work of this kind we find supplements the instructional work in the very best way and brings the instructors and students into intimate contact. The conference system not only does this, but it brings the students in contact also with all members of the instructional force in the department.

DISCUSSION.

PROFESSOR WALDO: Most of our engineering colleges require both plane and solid geometry of their students for admission. I think that the teaching of these subjects at the present time in the preparatory schools needs improvement, not so much in the amount covered as in the manner in which it is covered. The trouble in the high schools comes from the teachers having studied very little mathematics, if any, beyond the subjects they teach. Not having a good knowledge of the mathematical work which their students will be later required to study, they do not properly appreciate the importance of a thorough grounding in the mathematics of the high school.

But the most serious difficulty is to teach students how to study. Few of them seem to know how to study mathematics. They set about it as something to be memorized. On account of the increase in the number of subjects taught in our preparatory schools, and the covering of too much ground with a very thin layer of knowledge, the same is probably true of several other subjects. Students seem to get the idea that superficial knowledge is adequate, and that this is true of mathematics. They fail to grasp and retain the fundamental principles and to appreciate the fundamental facts.

Professor Norris: The question is raised, "How are we to influence work at the preparatory schools?"

Professor Marvin: I would like to know how much is done by other states in regard to bringing the secondary school people into touch with the university. In my own state we have a conference with the high school people, which is usually held at the university in the spring.

We make it worth their while by furnishing an attractive program, which includes papers from the university people and from the high school people themselves; also something in the way of a lecture by some outside party. Each year some subject is taken up for discussion—one year mathematics, one year English, and one year modern languages, etc. This actual coming into close touch has been found to be of great benefit. One result in my own state has been the formation of a mathematical society along the lines of a secondary mathematical organization, made up of high school principals, superintendents of schools and teachers of mathematics in various colleges of the state. This organization is alive and working and is influencing the teaching of mathematics, and I think the situation in Kansas is going to be improved.

PROFESSOR D. C. JACKSON: To illustrate how unsatisfactory it is to allow secondary scholars to carry on for a time an analytical study, which is preliminary to similar work in the college, and then drop it, allowing a gap between the times when the scholars pursue the study in the secondary school and in the college, I will relate an experience of some ten or twelve years ago. Some of us believed that algebra was not well enough taught in the secondary schools, while some others of us insisted that the fault lay in the time it was taught, which allowed a gap between the study of the subject in the high schools and in the college. Our mathematics department was influenced to examine in algebra every scholar coming from high schools at the beginning of a particular college year. I am connected to a university receiving, as you know, a large number of scholars on certificates from high schools, in lieu of entrance examinations.

We took the results of the examination and plotted curves on the basis of the percentages of scholars who went through an easy examination with a record above passing mark for one coordinate, and the other coordinate was the number of years prior to this examination when the several students last studied algebra. The class included scholars whose preparatory study of algebra had ceased as much as six or eight years before coming to college, while others had studied it up to the day of this examination. For most of the scholars there had been a gap of a year or a year and a half. It was remarkable to see the uniformity with which the relative numbers who failed to pass an easy examination were almost proportional to the lapse of time between the studying of the subject and the coming to college. As a result of this examination, the University of Wisconsin placed a recommendation in its catalogue that algebra should be reviewed in the last year of high school work. This recommendation, however, did not do much good because the secondary school disregarded it.

A recent crusade of the same nature has brought about with us the introduction of an algebra examination for all entering students who come to the college of engineering, with the understanding that whether a man be entered from an accredited school or not, if he does not pass the algebra examination, he is excluded from entrance.

The condition referred to is not one that relates to algebra alone. It relates generally to analytical studies. Those studies which relate to facts and which are not to be articulated with the college course are just as well studied in the first year as in the last year of the secondary school course, and we do not care whether they are studied continuously throughout the secondary school course or not. An analytical study, on the other hand, should be closely articulated with the college course. The early study of algebra helps arithmetic, which of course is an advantage, but if algebra is studied in the first year of the secondary school course, it ought to be taken up again at a later time so as to articulate it with the college course. This also results in articulating arithmetic and geometry with the rest of mathematics, which is highly desirable.

PROFESSOR LANDRETH: To those who are not familiar with the procedures of New York and the eastern states, I would say that we have what is known as a Uniform Examination Board which examines students of the different schools and issues certificates which are accepted as an equivalent for examination for admission to any college represented on the board. While this is an improvement, it has not yet solved the problem. There seems to be a feeling that what is needed is either to have the board take on a new function or to establish a new board which shall undertake the examination of high school students, and prepare a certified list of what may be called accredited schools, to which list names may be added or dropped as the work of the school, as seen in its students, seems to warrant. As the work of any school improves, it will become eligible, and its name added to the list by the board and the certificates issued by the board will be accepted by the colleges. This proposed scheme may furnish one of the remedies which are asked. Then if students from a certified school indicate a low grade of work as being done by the school, any college may, at its discretion proceed to require entrance examinations of the students coming from that school. Whether or not this will meet the difficulty remains to be seen. It may be necessary for the schools to return to the old plan of holding their own examinations and not accepting the rating of the Uniform Examination Board.

PROFESSOR TYLER: Some reference has been made to New England conditions. Several New England colleges belong to the College Entrance Examination Board of which all accept the records. We have beside that in New England a Commission of Colleges which makes up a list of schools. This accredited list is weeded out from time to time on the basis of records of students in the colleges. The commission includes naturally only those colleges which admit on certificate. I think the most helpful change in New England recently has been the increased development of interest in the association of teachers of mathematics and other subjects. The same movement is going on in all parts of the country.

In regard to the special question of entrance mathematics, we have recently tried a plan which I think produces good results, viz., that of holding two examinations in algebra, each of one and three quarters hours. The school-men have insisted frequently that they cannot arrange their programs so that algebra will be included in the final year of the high school work. Our reply has been that in the early years of the high school course, the boy is incapable of doing justice to the subject, that he gets this in an unsatisfactory way and that the geometry had better be finished earlier and algebra taken in the last year as well as first. We do not consider a boy in general well prepared for our work unless he has studied algebra during the year before his entrance.

As given now in most high schools, at least in New York state, algebra is studied in the second year, or rather two years before the year for graduation, and by the time the boys get through their course they have forgotten nearly all they have learned. This had been remedied in New England by requiring a review in the last year of preparatory school work. This is somewhat of an improvement.

PROFESSOR WALDO: A word in reference to our practice in the Central West. Our entering students may be divided into two classes; those who are known as graduates from accredited high schools or certified schools, and those who are not. The second class includes those students whose work in high school has been interrupted by necessity. After they have been in practical life for a time, they discover the need of a higher training. These we examine in every case and those who are able to stand a pretty stiff examination in a number of subjects, but especially in mathematics, are usually given a trial. They are usually mature men. They know what they want, and should succeed even with a handicap. The accredited students, numbering about 80 per cent. of the entering class, are looked after in another way. An individual record of their institution is kept, and when the work of students from any special institution is found defective, it is struck from the accredited list and its students must stand examination. In this way a pretty uniform set of entering men is secured.

PROFESSOR J. P. JACKSON: I desire to congratulate the author of this paper upon his lucid and commonsense presentation. There is one point to which, however, I take exception. That is the author's statement that less men have probably entered the field of pure science during the last few years than formerly because of the tendency of educational institutions toward the teaching of applied science and mathematics. Unless my casual observation is wrong, I should say that during the past few years there have been more advances in our knowledge of natural phenomena obtained by the work of scientific investigators than during any decade of the last century. Unless I am wrong in this, the author's statement at the beginning of his paper is certainly not based upon facts.

PROFESSOR WALDO: From some statistics it would appear that the growth in our general courses has been greater than it was before the rush for technical education. The University of Michigan may be taken as a Western type. An investigation shows the remark just made is true in that institution.

Ten years ago the school of liberal arts at Ann Arbor had a membership of about eleven or twelve hundred. Until about 1900, or 1901, it remained nearly stationary at that number. In 1903, the school of liberal arts had a membership of 1,300. Just previous to that time the University of Michigan entered upon the development of its engineering school, which in 1903 numbered about 600. In 1906, the school of liberal arts had increased to about 1,400, as over against no increase for the last few years up to the time of active work in the school of engineering, while the school of engineering had increased to 1,300. While the school of liberal arts did not increase at any such ratio as the technical, yet it seemed to derive a great stimulus from the rapidly growing school of engineering.

PROFESSOR JACOBY: The speaker would like to ask the question whether any one present has made the experiment of holding conferences with students for the purpose of replacing a part of the ordinary form of recitations? The paper seems to indicate that a conference was held to supplement the regular work. If the regular work was modified in any other way, it would be desirable to know more of the particulars.

It is certainly worth while to consider how the time may be reduced that is ordinarily spent by the student in recitations without lowering the standard of instruction.

THE STANDARDS TO BE PLACED BEFORE THE YOUNG ENGINEER.

BY JAMES PHINNEY MUNROE,
Treasurer of the Munroe Felt and Paper Company.

A major reason for the ineffectiveness of much of our public schooling is that teachers and pupils have their eyes and thoughts fixed, not upon the real purpose of education, but upon the examination of next week or the promotion of next June. The school and its processes become to them, therefore, ends in themselves. The petty lessons which they teach and learn obscure the broad objects of teaching and of learning, and the walls of the school-room limit their educational horizon. To neither such teachers nor such pupils is it ever revealed that schooling is but a minor means to the true end of education which is, of course, physical, mental, moral, and therefore social efficiency.

The students in a school of applied science have a wider view than this; but in most cases it is an outlook far too narrow. They are aiming, it is true, towards the goal of a professional career; but they usually see in that future profession not an opportunity for social usefulness, not the happiness which is reached through efficiency, not the unselfish devotion of (for example) the "born" physician; they anticipate, on the contrary, merely the power, the money and the ultimate ease which professional success may bring. Therefore, few undergraduates study the subjects in the curriculum because they care for them or because they grasp the relation between those topics and the social organism; they pursue them simply because those subjects must be overleaped—like obstacles in a hurdle race—by the irksome process called examination, in order to secure a degree. The degree itself they look upon as an end worth working for, since its possession means, usually, a remunerative "job" which will lead to others bringing in, eventually, an income adequate to the bewildering calls for expenditure in modern life.

Were this the attitude of mind of technological students alone, it might justify—or at least explain—the sometimes supercilious attitude of the college of "liberal arts," and might support its contention that its atmosphere is broadly cultural while that of the college of science is narrowly utilitarian. But under modern conditions the outlook of all collegians is practically the same; for, however fondly the elder institutions may cling to outworn forms and terms, however prominently the "humanities" may stand out in their prospectuses, they also are, in truth, colleges of modern science and of the application of science to commercial and industrial life. The cloistered student wrapped in love of ancient learning is still to be found; but he is engulfed in the host of youth who—when they do not go to college simply for sociability and prestige—regard higher education as a kind of trump card in the game of money-making.

More or less unconsciously, colleges of arts and colleges of science alike foster this student attitude of mind by devoting an undue share of the academic year to examinations, by overloading the curriculum with examinable subjects, and by permitting the several schools or departments to emphasize the utilitarian by specializing and intensifying too much. As a result the secondary purpose of a college—that of instilling information—too often bulks largest in the eyes of all concerned and obscures, or even eclipses, the leading aims of all collegiate education.

Those major aims should be in the order of their importance: (1) To develop manhood out of boyhood; (2) to make the men thus developed broad-gauged, mentally quick and receptive, intellectually catholic, tolerant and modest; (3) to train good citizens, in the fullest meaning of that term; and (4) to equip for industrial and professional efficiency. To accomplish the last is what the technological school is paid especially to do; but unless that professional training is given in such a way as to supplement and strengthen in the highest degree all the other social forces which are making for manhood, breadth and citizenship, the school has defrauded the undergraduate, has failed of its duty as a social agent, and has sealed its own eventual doom.

Even though they be nineteen or twenty years of age, most youth come to a college mere boys in their childish attitude of mind, their undeveloped sense of personal responsibility, their hazy outlook upon life, and their distorted perspective of themselves in the community. They ought to be graduated, however, with their minds ripened and their vision cleared. Indeed the years of their college life will have been largely wasted unless, in those years, they have acquired a mental and moral seriousness far greater than that of the less well educated man.

Limiting ourselves to the school of applied science, perhaps its paramount duty and opportunity is to impress upon a youth as he enters manhood that living, instead of being a game of pleasure or of chance, or a haphazard acceptance of what comes along, is an actual profession, is the leading vocation of every man, is a profession to be studied, perfected and strategically planned with interested thoroughness and far-seeing care. This right view of life can be instilled not only by giving the college youth ever wider choice of work, initiative in working and responsibility for the quality of his work (while holding him to a rational and ordered sequence of development), but also by teaching him such things and in such a way as to make him increasingly aware of a man's power over circumstance and of the multiform opportunity which every individual has to shape his own career.

Another chief use of the education given in a scientific school should be to expand a young man's vision, to teach him the difference between the small and the great things of life, to train him to see the world from a clear mountain-peak of intellectual tolerance rather than from a foggy valley of personal prejudices. This breadth and catholicity can be inspired by building all his professional and technical training upon basic truths and principles, by framing his courses of study upon those still fundamental, historical, philosophical and linguistic subjects which (quite too exclusively) made up the college course of half a century ago, and, most of all, by seeking every opportunity to impress upon each student the fact that what makes for leadership and power in professional life is not familiarity with technical details and an extraordinary memory for formulæ, but ability to view questions in a large way, to handle subordinates easily and justly, and to meet equals and superiors tactfully and upon the broad platform of many human as well as professional interests.

A student will not have secured seriousness and breadth, however, if, on graduation, be believes that his professional training is to be used wholly to satisfy his personal—and very proper—ambition for power and wealth. He must also have been made to realize that, being an extraordinary debtor to society, he owes an immense debt of future service to the community; he should also have learned that the main business of an educated man is to grow into wide usefulness by practising the "gregarious" virtues, by placing his abilities as far as possible at the service of his neighborhood and state, by increasing the five talents of his collegiate training into the many times ten talents of personal and social efficiency. To this end his technical and his non-technical teaching should have emphasized those subtle, unselfish moral qualities which lie at the foundation of professional ethics, engineering honor, and true devotion to the good of the state.

Whatever may be the sequence of studies, the ramification of "electives," or the emphasis upon this topic or upon that, the student should never be allowed to become so confused by these details as to lose sight of what he goes to a school of applied science for. In the student's own mind he goes primarily to obtain certain information, some technical skill and a measure of scientific jargon which will enable him to secure and to hold a remunerative professional position. If this mental attitude is not rectified, or is encouraged by placing too much emphasis upon technical information, "knacks," formulae and phrases, the youth will devote himself zealously, even enthusiastically, but none the less fatally, to things which, without the higher aims, are but the chaff of education. The strongest evidence of a freshman's need of training is that he does not know how to appraise those tasks which he must or may do, that he does not understand what the world is going to demand of him as the price of real professional success.

To educate him, therefore, in the right meaning of education, the school of applied science must not content itself with giving him that technical information which, to his untrained mind, is all that he requires; it must hold before him and must teach him to understand the value and importance of those higher standards by which his work as a man and as an engineer will be judged by his future employers, by his coming associates and by the world at large. He cannot foresee, therefore he must deliberately be made to appreciate, that behind and underneath his technical information and scientific skill he should possess at least three other things: seriousness of view, breadth of mind and a sense of civic responsibility. With the first he will learn how to measure and control his own life; with the second he will learn how to estimate the lives of others; with the third he will learn how to place himself and all he does into right perspective with the whole order of society; and with all three together he will be ready to meet and conquer practically every one of those problems—moral, social or technical, with which his life is certain to be filled.

To keep these large purposes and true aims of education before themselves and their students is extremely difficult for the teaching staff, engrossed as they must necessarily be in the thousand details of teaching and discipline, and hounded as they are from without and within to equip their students (like automobiles) with every latest device for technical speed and efficiency. That the faculties of most schools of technology have been able to preserve the wider view is cause for wonder and congratulation. With the greater specialization and haste of modern life, however, they will find this to be increasingly difficult unless they receive organized and unflagging help from those who stand far enough from the details of teaching to see that teaching in proper perspective and to measure its real results. The two bodies near enough to the school of applied science to understand its internal methods and aims and yet far enough away from it to gauge its final influence upon young men and its ultimate effect upon the industrial and social structure, are, of course, the trustees and the alumni. In every way possible they should identify themselves with their college and its undergraduates, and, while refraining from interference with the details of courses or of teaching, should keep clearly before the students those real aims and ends of all higher education which their experience of life should have made them plainly see. Just how they are to do this is not within the present scope even to suggest; moreover no two colleges of science would approach the problem in similar ways. But that these high standards must be held before the undergraduates of all such colleges and that the trustees and alumni must give conspicuous help in doing so are, I think, self-evident truths in higher education.

BLANK FORMS FOR USE IN ELECTRICAL ENGINEERING INSTRUCTION.

BY HENRY H. NORRIS,

Professor of Electrical Engineering, Cornell University.

The purpose of this paper is to set forth the facts regarding the use of mechanical means such as blank forms in connection with courses in electrical engineering. The state of affairs is practically the same in connection with other branches of engineering, but attention will be largely confined to this one branch in order to make the results more concrete. That the subject is worthy of study is evident from the fact that there is a great variety of opinion as to the wisdom of using such forms and the forms thus actually in use are of many different types. In presenting this topic to the society the writer has in mind the possibility of such an interchange of opinion and experience in connection with the discussion that the way may possibly be opened for preparing sets of standard blank forms which can be used in classes taught by our members. These forms are expensive to produce, especially in small quantities, and they require a great deal of care and thought to arrange in the most orderly and logical manner. Hence, if the use of blank forms is desirable and if some of these forms could be made standard, it would be entirely practicable for the society to undertake such work if it were thought wise.

In studying this subject two facts are clearly brought out. First, that any kind of instruction is primarily for the purpose of developing the ability of the student to think for himself; and second, that the instruction should give the student facility in turning out a great deal of good work in a limited time. Each feature of instruction must be adopted with these two points in view and any plans which emphasize one at the expense of the other will produce unsatisfactory results. Aside from these considerations, there must be kept in mind the necessity for efficiently instructing a considerable number of students, and a plan that might be successful with a large number of students may not succeed with a small number, and *vice versa.* From these premises it is evident that there is no definite answer to the question, "Are blank forms desirable for use in electrical engineering instruction"?

Experience with students teaches that very little pedagogical value is to be attached to lectures and recitations except as these force the students to put forth mental effort in doing something for themselves. Hence the necessity for an unlimited number of problems both analytical and experimental. These problems must be designed to teach the desired lessons without unnecessary drudgery, and they may at the same time serve to convey a general impression of current engineering practice. The preparation of the problems and the examination of the results entail much labor on the part of the instructors, and this may be minimized by the use of printed or mimeographed blank forms calling for the several items desired. With such forms in use the instructors are able to devote more time to the general principles involved and their work is rendered less tedious. The students are also helped by the forms in that they are able to go ahead with their work with little delay, and if the forms are properly designed the students will not be relieved of the necessity of thinking for themselves. Obviously, students are not prepared to plan their own problems and experiments in detail, for to do this requires a comprehensive view of the whole subject covered. They would be sure to omit important features, requiring the repetition of much work. The forms indicate the various features of the problems and the number of calculations or observations to be made. The objection to such mechanical helps is that the students are relieved of responsibility and hence have less incentive to think for themselves. This last-named feature constitutes a real danger and it must be avoided in some way.

In order to ascertain the present opinion and practice in regard to the use of blank forms, a correspondence was conducted with a large number of engineering schools, and the professors of electrical engineering were asked to state their views for the benefit of the society. A collection of blank forms was also made and arranged in book form for study. The results of this preliminary work show that opinion regarding the advisability of using blank forms varies from one extreme in which it is not thought wise to use any blank forms, to the other in which the general use of blank forms is recommended. The arguments advanced in the first case are that the student must be encouraged to put forth all the original effort possible and that he gains more by doing a few pieces of work thoroughly from the bottom up than from doing a great quantity of work with mechanical assistance. In one institution the aim is stated to be to have so many instructors in the classes that the students can receive the necessary help without the aid of many blank forms. Those who advocate the use of blank forms to a considerable extent believe that the student gains more by covering a great deal of work in a limited time than he does by doing a few pieces more thoroughly. The average opinion of all seems to be that a limited use of blank forms is desirable and that certain studies lend themselves more readily to the use of such forms than others. As a study tends to involve empirical information the use of blank forms becomes more allowable. This class of problems includes particularly design and work of this kind. It may be said also that problems connected with the prediction of the operation of electrical machines also come under this head. Laboratory problems seem to require a limited use of forms. One authority who was consulted gave as his opinion that blank forms should generally be used in order to produce facility, but that a few problems in each course should be given without any such assistance in order that the student might be able to try his own ability to follow through a line of thought. This seems to be a rational attitude.

A few notes regarding the practice in various institutions may be of interest and are here given.

Syracuse University uses a complete and elaborate set of blanks for data on dynamos, motors, etc., these being the most complete that were submitted.

Columbia University, for laboratory reports, uses a simple form calling for a few general matters and leaving the students to fill in the details. In the design courses, however, a more elaborate blank is employed and the completeness of the latter is shown by the fact that for dynamo and motor work the list comprises 327 items. Columbia University submitted an interesting blank form to be used in describing an electric light or power station calling for the various items necessary to completely describe such a plant.

In the electrical laboratory of Montana State College a small size of report form ($7\frac{1}{2}$ x $8\frac{1}{2}$) is used, the standard apparently being $8\frac{1}{2}$ x 11.

The University of Missouri uses in the designing room a complete form for dynamo electric machinery covering all kinds of electrical and mechanical details.

The University of Vermont has a very complete set of blanks for experimental work and design.

The Armour Institute sent a sample blank covering the subject of power plant engineering in which the important details of dynamo and motor construction are compactly arranged.

Ohio State University uses detailed forms for design, but for laboratory reports finds it more desirable to merely indicate the important features, allowing the students to fill in details.

Cornell University uses a large number of blank forms, Professor Carpenter of the Experimental Engineering Department having developed a very complete set covering all of the experiments performed in the junior and senior laboratories. At the present time a set is being developed for the electrical engineering laboratory, the arrangement being based upon the experience gained in the experimental engineering department combined with the requirements of an electrical laboratory. Samples of both of these forms are submitted, as they show a successful practice in this line. The experience in Sibley College has shown the necessity for the use of such blanks, particularly in the instruction of large classes. The blanks have been so prepared that they contain all necessary information for carrying out and working up the experiments as far as this can be given in condensed form. In the electrical engineering department, aside from the laboratory, it has also been found very desirable to put the problems and other exercises into systematic form, the constants being varied so as to give individuality to the work of each student.

Blank forms received from the Charlottenburg Technical High School and designed by Professor E. Arnold are as complete as any that have been available. The most minute details are covered and if a student has thoroughly solved one of these problems he is presumably a master of the subject.

Two very interesting volumes were submitted by Professor W. S. Aldrich as samples of the methods followed by him in his recent work at the University of Illinois. Detailed instructions are given for conducting the experiments and some blank forms are included, the spaces to be filled in by the students.

The University of Texas submitted a number of sample reports from students, from which it is evident that they do not supply printed forms but they depend upon the students to rule their own blanks as needed. The experiments are inclosed in standard covers, on which are printed general instructions for conducting experiments.

In conclusion the writer would state that for the conditions existing at Sibley College he feels sure that some blank form must be used for practically every problem or experiment. That this is true in all institutions is doubtful. It will be interesting to learn the opinions of the members of the society as to whether the enforced use of these forms is an unmixed evil or whether as good results may be accomplished with a judicious use of the forms as without.

EXAMPLE OF SIMPLE LABORATORY REPORT COVER.

Columbia University in the City of New York.

Electrical Engineering Department.
Laboratory Report on

Experiment No. .... Part ....
Name .... Dates examined (1) ....
Date commenced .... (2) .... (3) ....
Date completed .... Mark ....
Date handed in .... Signed ....

This report is due one week after the date of completion of the experiment in the Laboratory.

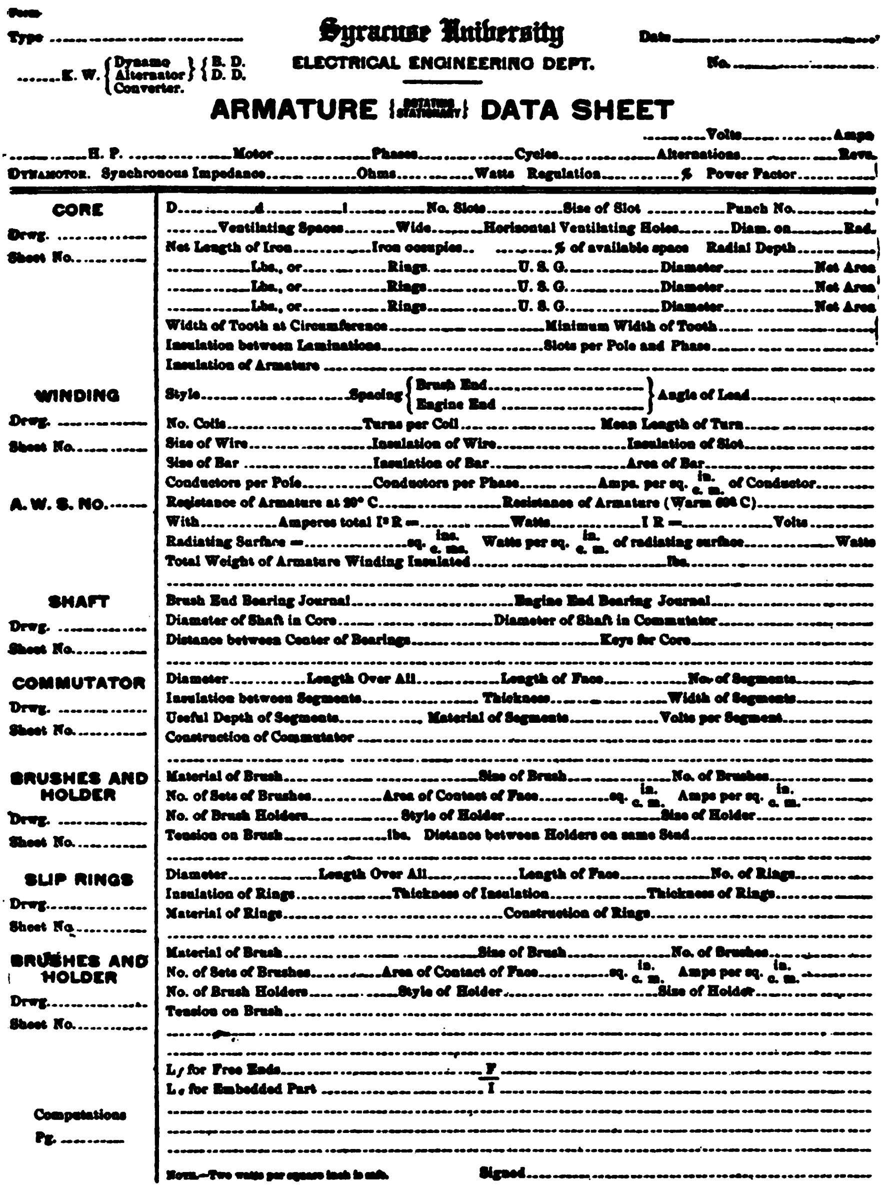
1. Title ....
....

2. Object of experiment ....
....
....

3. Apparatus employed (Laboratory numbers and ranges of all instruments and apparatus. Names and capacities of all machines) ....
....
....
....

4. Description of the experiment with observations, curves and conclusions ....
....

TYPICAL FORMS FOR TABULATING DATA.



Form

Type ......

Syracuse University

Date ......

......K. W. {Dynamo / Alternator / Converter.} {B. D. / D. D.}

ELECTRICAL ENGINEERING DEPT.

No. ......

ARMATURE {Rotating / Stationary} DATA SHEET

......Volts......Amps

......H. P. ......Motor......Phases......Cycles......Alternations......Revs.

Dynamotor. Synchronous Impedance......Ohms......Watts Regulation......% Power Factor......

CORE

Drwg. ......

Sheet No. ......

D......d......l......No. Slots......Size of Slot ......Punch No. ......

......Ventilating Spaces......Wide......Horizontal Ventilating Holes......Diam. on......Rad.

Net Length of Iron......Iron occupies.. ......% of available space Radial Depth......

......Lbs., or......Rings......U. S. G. ......Diameter......Net Area

......Lbs., or......Rings......U. S. G. ......Diameter......Net Area

......Lbs., or......Rings......U. S. G. ......Diameter......Net Area

Width of Tooth at Circumference......Minimum Width of Tooth......

Insulation between Laminations......Slots per Pole and Phase......

Insulation of Armature ......

WINDING

Drwg. ......

Sheet No. ......

A. W. S. NO. ......

Style......Spacing {Brush End...... / Engine End ......} Angle of Lead......

No. Coils......Turns per Coil...... Mean Length of Turn......

Size of Wire......Insulation of Wire......Insulation of Slot......

Size of Bar ......Insulation of Bar......Area of Bar......

Conductors per Pole......Conductors per Phase......Amps. per sq. in./c. m. of Conductor......

Resistance of Armature at 20° C......Resistance of Armature (Warm 60° C)......

With......Amperes total I^2R = ...Watts......IR = ...Volts ......

Radiating Surface = ...sq. ins./c. ms. Watts per sq. in./c. m. of radiating surface......Watts

Total Weight of Armature Winding Insulated......lbs.

......

SHAFT

Drwg. ......

Sheet No. ......

Brush End Bearing Journal......Engine End Bearing Journal......

Diameter of Shaft in Core......Diameter of Shaft in Commutator......

Distance between Center of Bearings......Keys for Core......

......

COMMUTATOR

Drwg. ......

Sheet No. ......

Diameter......Length Over All......Length of Face......No. of Segments......

Insulation between Segments...... Thickness......Width of Segments......

Useful Depth of Segments...... Material of Segments......Volts per Segment......

Construction of Commutator ......

......

BRUSHES AND HOLDER

Drwg. ......

Sheet No. ......

Material of Brush......Size of Brush......No. of Brushes......

No. of Sets of Brushes......Area of Contact of Face......sq. in./c. m. Amps per sq. in./c. m. ......

No. of Brush Holders...... Style of Holder......Size of Holder......

Tension on Brush......lbs. Distance between Holders on same Stud......

......

SLIP RINGS

Drwg. ......

Sheet No. ......

Diameter......Length Over All......Length of Face......No. of Rings......

Insulation of Rings......Thickness of Insulation......Thickness of Rings......

Material of Rings......Construction of Rings......

......

BRUSHES AND HOLDER

Drwg. ......

Sheet No. ......

Material of Brush......Size of Brush......No. of Brushes......

No. of Sets of Brushes......Area of Contact of Face......sq. in./c. m. Amps per sq. in./c. m. ......

No. of Brush Holders......Style of Holder......Size of Holder......

Tension on Brush......

......

......

L_f for Free Ends...... $\frac{F}{I}$ ......

L_e for Embedded Part ......

Computations

Pg. ......

......

......

......

Note.—Two watts per square inch is safe.

Signed......

Mechanical Laboratory—Sibley College, Cornell University.

Data and Results of Test of .... *Oil Engine*

By *190*

Object of Test ....

Dimensions of Engine.

Rated H.P. at .... R.P.M. =	
Diameter of piston .... In.	
Area of piston .... Sq. in.	
Length of stroke .... Ft.	
Piston displacement .... Cu. ft.	
Clearance .... Cu. ft.	
" .... Per ct.	
Diameter piston rod .... In.	
" crank pin .... In.	
Length of brake arm	
Scale of indicator spring .... lbs. per in.	

Data

Run No.	I	II	III	IV
Duration trial, hrs.				
Brake load, net lbs.				
Oil, total cu.in.				
Oil per hour, cu. in.				
Air, total cu. ft.				
Air per hour, cu. ft.				
Ratio air to oil by weight				
Jacket water, total lbs.				
" per hour, lbs.				
" tempt. entering, F°				
" " leaving, F°				
" range, F°				
Revolutions, total				
" per hour				
" per min.				
Cycles, per min.				
Explosions, total				
" per hour				
" per min.				
Ratio of explosions to cycles				
Temperature, exhaust, F°				
" room, F°				
" range				
Specific gravity of oil				
*Air, wt. of a cu. ft., lbs.				
*Mixture, wt. of a cu. ft. lbs.				
Specific heat, oil				
" air				
" exhaust gases				
Heat in one lb. oil, B.T.U.				

Run No.	I	II	III	IV
Results.				
INDICATOR.				
Maximum press., lbs. sq.in.				
Compression press., lbs. sq.in.				
M.E.P. power stroke				
" comp. "				
I.H.P. net				
D.H.P.				
Mechanical efficiency, per cent				
Friction horse power				
Oil per hour, pints				
" " " lbs.				
Weight of air per hr., lbs.				
" Ex. gases per hr., lbs.				
Oil per I.H.P., per hr., pints				
" " " lbs.				
" D.H.P " pints				
" " " lbs.				
Heat per hour.				
Supplied, ... B.T.U.				
" .... per cent				
Absorbed by jacket water, B.T.U.				
" " " " per cent				
Exhausted, ... B.T.U.				
" .... per cent				
Thermal equiv. Ind. work, B.T.U.				
" " " .... per cent				
Radiation and loss, ... B.T.U.				
" " .... per cent				
Thermal units per I.H.P., per hr.				
" " " D.H.P., " "				
EFFICIENCIES, PER CENT.				
Possible thermal = $\frac{Q-q}{Q}$				
Thermal from I.H.P				
" " D.H.P.				
Carnot = $\frac{T_{max}-T_{min}}{T_{max}}$				

*At 32° F and 14.7 lbs. absolute pressure per sq. in.

390K

DEPARTMENT OF EXPERIMENTAL ENGINEERING—ELECTRICAL LABORATORY.

SIBLEY COLLEGE—CORNELL UNIVERSITY.

LOADING POLYPHASE ALTERNATOR.

(Data Sheet.)

Date.............................Section .... Make.................................Type { revolving field / revolving armature

Observers: Volts.......................Amps.........................Speed.................

.... K.W...................Mfr's. No...............No. of Poles...............

.... Phase...................Alts........................Cycles...................

.... Driven by...

....

Y—Connection.

	Amperes				Volts.			Volts.			Watts.			Watts.		Total
	A	B	C	O	AB	BC	CA	AO	BO	CO	AO	BO	CO	A—AB	C—CB	Watts.
Inst. No.																
Const.																

Δ—Connection.

Amperes			Amperes			Volts.			Watts.		
A	B	C	AB	BC	CA	AB	BC	CA	A—AB	C—CB	Total

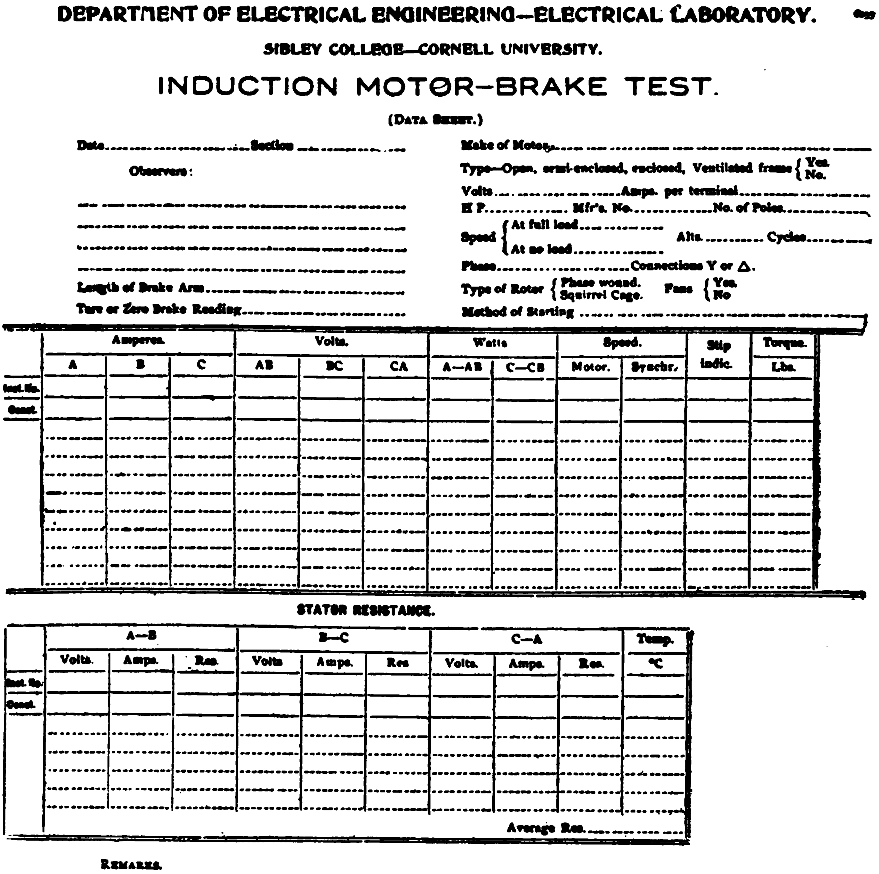
Remarks.

V—Connection.

Amps. Prim.			Volts. Prim.			Amps. Sec.			Volts. Sec.		
A	B	C	AB	BC	CA	A	B	C	AB	BC	CA

T—Connection.

Two Phase				Three Phase							
Amps.		Volts.		Amps.			Volts.				
AB	CD	AB	CD	A	B	C	AB	BC	CA	CD	AD and BD



DEPARTMENT OF ELECTRICAL ENGINEERING—ELECTRICAL LABORATORY.

SIBLEY COLLEGE—CORNELL UNIVERSITY.

INDUCTION MOTOR—BRAKE TEST.

(DATA SHEET.)

Date........................Section..................

Observers:

....

....

....

....

Length of Brake Arm..

Tare or Zero Brake Reading...................................

Make of Motor...

Type—Open, semi-enclosed, enclosed, Ventilated frame {Yes. No.

Volts........................Amps. per terminal..................

H P..............Mfr's. No..............No. of Poles..............

Speed {At full load.............. At no load.............. Alts............ Cycles............

Phase.........................Connections Y or Δ.

Type of Rotor {Phase wound. Squirrel Cage. Fans {Yes No

Method of Starting...

	Amperes.			Volts.			Watts		Speed.		Slip indic.	Torque.
	A	B	C	AB	BC	CA	A—AB	C—CB	Motor.	Synchr.		Lbs.
Inst. No.												
Const.												

STATOR RESISTANCE.

	A—B			B—C			C—A			Temp.
	Volts.	Amps.	Res.	Volts	Amps.	Res	Volts.	Amps.	Res.	°C
Inst. No.										
Const.										

Average Res..................

REMARKS.

DISCUSSION.

PROFESSOR BRACKETT: Professor Norris has not emphasized one thing which might be considered in favor of using standard blanks in laboratory work; that is, the aid they offer the instructor both in checking the observations before the student leaves the laboratory and in correcting the final report on the experiment.

When students work without observation forms, it is no unusual thing, especially if the instructors are over-burdened, as is often the case, to find that some most essential observation has either not been taken at all or was not recorded and has been forgotten.

Then the comparative ease with which reports arranged in some familiar form or order may be checked, criticized and graded is of no small convenience to those compelled to do that portion of the work. Perhaps the instructor's convenience ought not to be considered. It certainly should not be put before the interests of the student. But if the duties of the instructor can be made lighter without detriment to the welfare of the student, then it is desirable that it should be done.

The suggestion that some of the work be done with blanks and some without blanks is to my mind a good one. In fact there is little excuse for going to extremes with any one method in any subject. As a rule, some methods are good for certain portions of a subject and other methods are better for the remaining portions.

In the electrical engineering laboratory there is no doubt that more ground can be covered in a given time when blanks are used than when they are not used. I am inclined to believe that in most cases the greater amount of work performed is an ample justification for the use of blanks. Some experiments should be set aside, of course, to be reported in the student's own form. The form of these particular reports should be given considerable weight, not merely in the credit for the experiments so reported, but in credit for the entire course. The number of experiments required to be reported in the student's own method ought to be dependent upon how much he needs such training. Perhaps this portion of the work would better come first, and then when a satisfactory proficiency in formulating reports has been attained, recourse may be had to blanks and forms.

PROFESSOR F. C. CALDWELL: I am inclined to differ from the speaker with regard to the use of blanks and believe that their number should be kept as low as is consistent with the necessary guidance to the students in the matter of their preparation. It is important that students should learn to make their own blanks and to supply them with proper headings, and the capacity to do this can be developed better by practice than by the continual use of blanks already prepared. Of course the necessity for reducing the work to be done by instructors may require an extensive use of prepared blanks, but I believe it should be regarded as a necessary misfortune. I am always inclined to think twice about the educational value of a scheme which will result in saving work for myself.

PROFESSOR FORD: The question as to whether blanks are to be used in recording the results of laboratory work is determined largely by what is considered as the object of that work. If it is merely to determine the efficiency or other characteristics of a certain number of machines, as is done in a factory testing room, the use of record blanks is to be commended. If, however, the object is to teach the student how to obtain the machine characteristics, the use of blanks is of doubtful utility if not a positive detriment. The reason for my opinion is this: If a blank is to be used it is of necessity accompanied by a more or less detailed statement of the readings which are required, with the necessary calculations. Having these instructions before him the student is apt to fill all the blank spaces with readings without regard to why they are made or what they mean. The result is that if he is required to test a machine without a blank at hand he wonders how he is going to do it and the chances are that he will forget to take some important reading, while if he had had no blank in the first place he is much more apt to know what he is doing. To my mind the only excuse for the use of blanks is to save the time of the instructor when he is obliged to handle classes that are too large for him.

The case of design is quite different, for there the magnitude of the results is of quite as much importance as the method of calculation. Then too a tabulation of final results is merely a convenient way of asking for desired information. The use of blank forms for design appears highly desirable.

PROFESSOR R. C. CARPENTER: My experience, based upon actual results that men have accomplished after leaving college, has led us to adopt blanks to quite an extent in laboratory work. Our laboratory work is for the purpose of giving a man skill in doing certain things and in finding certain results. We use laboratory blanks merely as a means of recording results and to save the student a lot of time. This is important with us since men are required to do a good deal of work in a short time. The value of blanks depends largely upon the viewpoint and the object of the experiment and what you want to accomplish. If you want to teach your men to do a great deal of work very quickly and for some certain ends, you will gain more for yourself and them by using blanks.

We find that the use of blanks helps us out in the saving of an instructor's time to a great extent. We use them largely as printed instructions and as an expedient I believe they are necessary for many cases and not hurtful for advanced or research work, of which we do a great deal. An advanced student working on research work is encouraged to make his own blanks.

PROFESSOR J. P. JACKSON: Professor Carpenter's statement is undoubtedly in line with the best thought and practice of the men in charge of the experimental work of our leading institutions. I would like to suggest to Professor Norris in reference to his paper that if he will kindly make out blanks for the course in electrical engineering such as he considers ideal and append them to his paper for printing in the transactions, he will doubtless perform a valuable service for the rest of us.

PROFESSOR BRACKETT: Perhaps your instructors take the place of blanks. I have known cases where laboratory work was conducted in such a way that the student received verbally all the direction and all the help which a blank would give.

I have also known students to use the directions given in a laboratory manual in the same way that a blank would be used; and I have myself received reports in which the directions of some book, not even in the room when the observations were taken, had been followed as specifically as could have been those of a blank.

PROFESSOR H. H. NORRIS: In closing this discussion I would say that the remarks made during the discussion indicate a considerable difference of opinion as to the extent to which mechanical helps should be employed. We are, apparently, agreed that each institution must determine this matter for its particular circumstances. If, however, it is possible for the more complicated forms to be used by several institutions, some economy of money and effort would result. For the present I would suggest that those professors of electrical engineering, who care to do so, agree to send to other like-minded teachers copies of their printed matter. This would tend toward uniformity of practice as far as such uniformity is practicable and if it developed that certain of the forms have a tendency toward similarity some common action in regard to printing might be taken later. The writer will be pleased to receive the names of teachers to whom the above suggestion may appeal and he agrees to keep each supplied with a corrected list of the cooperating professors.

TOPICAL DISCUSSION: IS THE DESIGN OF ELECTRICAL MACHINERY A PROFITABLE UNDERGRADUATE STUDY?

PROFESSOR NORRIS: I have become impressed during the past few years with the notion that primarily a technical school is an educational institution. I find that engineering design as practiced by the engineering companies is largely of an empirical nature. If we teach in such a way as to illustrate simple fundamental principles, we will produce electrical machines which will not be anything like those turned out by the electrical companies, the latter type being designed to sell at a minimum price and maximum profit with reasonably satisfactory performance. As this is the case, machines being designed on a competitive basis, I have found the teaching of design to have become so empirical that the pedagogical value of it has been seriously impaired.

As an experiment this year, we have cut out the previously required work in electrical machine design and only give it to men who have expressed a preference for it, about 20 per cent. of the senior class. Of course, something takes the place of design. It is the prediction of the characteristic performance of electrical machines calculated from the dimensions of actual successful types.

PROFESSOR D. C. JACKSON: At the University of Wisconsin we never think of putting a man at the designing of mechanical details in the machine design department. I believe that this is one of the few subjects that teachers of engineering are agreed upon.

THE FUNCTION OF THE LECTURE IN TECHNICAL EDUCATION.

BY JOHN PRICE JACKSON,

Professor of Electrical Engineering, Pennsylvania State College.

The subject to which the following few words are devoted is rather an old one and quite hackneyed. As it is of much interest to the educator, however, and as there is still a somewhat striking variation in belief concerning the function of the lecture, these words may not be found to be entirely amiss. Further, if an apology is needed for this paper, I would suggest that we are prone to forget, in the glamor of engineering and scientific achievement, that our serious and important duty to humanity is the moulding of intellects, and that pedagogy and pedagogical principles lie at the very root of this endeavor.

The lecture as it is made use of in the class room may be conveniently divided into three classes: first, that which is copied by students verbatim; second, that which is delivered at the ordinary rate of conversation or reading and is taken down by the student in written notes as fully as possible; third, that which is given without notes being required.

The first type may be omitted from consideration, as it has been abandoned, at least in technical colleges, as inefficient. The second, unluckily, is still somewhat in vogue and it is concerning it that I would speak, as it is apt to prove a snare to the unwary freshman in his chemistry, physics or mechanics and a delusion to the professor who endeavors to use it as an aid in education. Take the example of a class that must absorb a large portion of a technical subject in the form of notes from lectures delivered in the class room. The professor stands at his lecture table and talks sometimes rapidly, sometimes slowly, illustrating his words by suitable experiments. The class is compelled to scribble down the statements made to them with the greatest possible celerity in order to obtain the required data. Many of the students, if not all, spend so much of their energy in the mechanical process of writing that they get exceedingly little appreciation of the meaning of the professor's talk. Further, though the writing of notes is done at the highest speed possible, the average is not over ten or twelve hundred words in an hour, not more than may be found on a couple of ordinary text-book pages. After leaving the lecture room the students are expected to decipher their hastily written notes, write them up in full, and give accurate descriptions of the experiments. This final preparation of notes means on the average from two and a half to three hours of hard work, the greater part of which is purely manual and of absolutely no value so far as the technical subject under consideration is concerned. That is, in four hours the student covers not more than two octavo pages, and the mechanical labor performed in the greater part of these four hours gives a kind of training which has no relation to the subject.

The notes made at the expense of such painstaking labor are not of intrinsic value and I am ready to guarantee are never looked at after graduation except as curiosities. Indeed, a well known professor of mathematics told me a few weeks ago that he possesses, packed away in his attic, something like a score of beautifully prepared notebooks, which he was compelled to make while taking an advanced course in one of the great universities of this country. He said he never thought of referring to them in his work; at the same time he pointed to his bookcases, filled with some hundreds of substantially bound printed volumes, saying that he kept his references there. It must be generally conceded that, if desirable text-books on the subject studied may be obtained, the student can spend his time to much greater advantage than in note-taking and copying. But, of course, it is true that suitable text-books are not to be found in some subjects and also that collateral reading may need binding or correlating. However, admitting these facts, does that give a professor of science a right to turn so large a proportion of his endeavor to the training of a writing or copy-book class? Let the department of English attend to such classes. Certainly any instructor who is not willing to use text-books or other material available can duplicate, either by the aid of printer or mimeograph, notes that will meet his purposes or approval for distribution among the students under his direction—if necessary, the students would gladly bear the expense. Such a course means work, hard work, for the instructor, and if he is unwilling or unable to afford the time for it had he not better use the best text-book to be had, modifying it here and there as occasion demands by some means other than those which are at the expense of the students' time. The instructor who believes it impossible to teach his subject by any method but the note-taking lecture will not, let it be hoped, bring forth the argument against printed or mimeograph outlines that his work is not in sufficiently correct form for permanence, as under such conditions it can hardly be expected that an inexperienced student will be able to formulate notes upon which he can rely. I once knew a competent professor of machine design who was at one time a firm believer in the note-taking lecture system, his sole argument being that it taught his boys to make notes properly. I was entertained to observe but a few years later that he had converted his lecture notes into a printed text-book. His boys are undoubtedly taught as well as before how to keep an engineer's note-book, while they are receiving infinitely greater benefit from their class work and the elucidations of their teacher.

What are the advantages to the student of eliminating the taking of notes? In the first place, instead of the contents of about two printed pages the student can prepare and be drilled in the work of from six to ten or more pages. Instead of having to decipher facts from hastily scrawled notes taken under pressure and usually incomplete and full of errors, he has the subject before him either in clear typewriting or in print and is thus in a far better position to get at the truth. Again, and this is the most important advantage, during the hour of the lecture or recitation the student gives his entire and concentrated attention to the subject. The lecturer who places finished discussions or a text-book in the hands of his men, instead of talking to a few score of pencils or notebooks, speaks directly to the minds of his hearers. He is able, therefore, to impress his personality upon them; in the speaking countenance before him he reads comprehension or its lack, and he does not leave his subject until he has made his thought lucid. Under these conditions the teacher has full opportunity to enthuse his students with a true inspiration for knowledge and a desire to get to the bottom of the subject. When talking to notebooks rather than minds it is next to impossible to create any such enthusiasm. I refer you to Spencer, or any other great educational writer, for proof that this is good pedagogy.

The technical instructor is recompensed more generously than is necessary for the services of a mere drill master, quizzer or reader of lectures. This recompense is given not only on account of his broad knowledge of the subject, but also very largely for his ability to give those under his instruction the personal inspiration of which I have spoken. A college faculty of drill masters can drive students to work with much diligence in preparing their lessons for the purpose of making good recitations and examinations, but at the end of four years under the direction of such a faculty a young man, even though he be graduated with honors, may be both superficial and lacking. He will be lacking in the initiative, the ability to reason for himself, the breadth of grasp, and the logical processes of mind that are developed largely by personal contact with teachers who can inspire a true love of knowledge, divorced from the machinery of grades and examinations.

"What is the most difficult task in this world"? asks a great philosopher of himself and replies, "To think." This question has been so asked and answered many times in this meeting. It is to train young men to think after having inspired in them a love of knowledge, that is the duty of the scientific teacher; and to think, he must be taught to understand the impressions he receives and to draw deductions therefrom. This is pure Emersonian teaching. The instructor is presumably a thinker; if he is not, he should not be a teacher. He should be able to impress his mental processes upon a boy developing under him. In order to do this he must make himself mentally transparent to the untrained minds about him. Certainly the instructor does this most fully who, while standing before his class, holds every eye and is in intimate communion with every mind; he is able then to perceive just how far his ideas and thoughts are absorbed and how much they rebound from unresponsive intellects; and he is able with this knowledge to so vary his presentation that it will have many sides and points of view until finally it becomes acceptable to even the most sluggish minds in the class. Frequently before the inspector has graven the impression of his ideas upon each mind it is necessary for him to make use of one or more of those under his instruction, calling upon them to express in their own words, with suitable guidance, the thoughts to be developed.

It is evident that if the lecturer, or better the teacher, wishes to impress himself and his knowledge upon his class, his whole mental force must be expended directly upon the minds of those whom he would influence, unhampered and unhindered by constraint or barrier of any kind. Lecture notes written by students or any other similar distractions seriously hinder the accomplishment of this object and should therefore be rigorously eliminated.

Let the student have a text-book if possible. If this is not available, let him have at least a set of prepared lecture notes; assign him all the references and collateral reading that he can master; but when lecturing to him or rather teaching him, do so untrammelled by any conventional barriers that will weaken the impress of your thought upon his mind. Whatever excuse may be offered for hampering, by the lecture method, the instruction of upper classmen in applied science, which is ever changing, there can be no semblance of an excuse for injuring the work of freshmen or sophomores by burdening them with the lecture note system or any other similar scholastic contrivance.

These suggestions apply not only to engineering subjects, but also to chemistry, physics, mathematics; indeed, to all study not devoted solely to the cultivation of the memory.

DISCUSSION.

PROFESSOR MERRIMAN: There are two ways in which the student can take in ideas and make them his own, by the eye and the ear. The eye method is that of the reading of books; in the ear method the student hears the words of the lecture. Both methods have their advantages, but it seems probable that the average boy can more easily take in ideas by ear, and therefore it does not seem best that instruction should be given solely by text-books.

Every one present, when going away from here this afternoon, will have a clear idea of what has been orally given by Professor Jackson. Had we read the same matter in print, the impressions in our minds would certainly have been much less definite.

PROFESSOR F. C. CALDWELL: I agree most fully with the author of the last paper in the matter of keeping up of lecture notes. I have always felt that the copying of the lecture notes is usually a misuse of the student's time. As a general thing, lecture notes are of little value as a permanent possession, though as a means of acquiring the information covered by the course, they may be valuable if properly taken down and worked up. Most students need careful instruction and training in this matter and the practice which a student can thus obtain in taking down the essential features of a subject without attempting to write it out verbatim, is most valuable and I believe should form a part of every student's training. In my own work I urge the students not to copy their notes, but to learn to take them down in such shape that they can make use of them afterwards.

Professor Swain: I agree entirely with the author of the paper, if I understand him correctly. I think the character of the notes should depend upon the character of the subject. In theoretical or mathematical subjects, where students should frequently stop to think, I think the lecture system is not applicable. In such courses a text-book should be studied outside.

Professor Merriman: I do not think the lecture method is applicable to mathematical subjects. There are, however, many topics which can be advantageously presented in lectures, especially descriptive subjects like that of sanitary engineering, and this method seems to give a greater interest to students than when they read a book and recite upon it. It is a benefit to a class to take notes of lectures, because the ability to take notes and to properly reproduce and expand them is a desirable accomplishment. The copying and reproduction of the blackboard sketches used in a lecture is also very profitable. Many lectures should not be given, but two or three per week afford a pleasant change from reading and formal recitation.

Professor Swain: Regarding Professor Merriman's remarks, I should like to ask how far he considers it desirable to go into descriptive work in engineering courses. Some subjects involve a great deal of descriptive matter, and lectures on such subjects have their proper place in that kind of work. For my part, my tendency is to give less and less descriptive work, going into it only so far as to illustrate principles. I think we are trying to teach too many things in our engineering schools, and that we do not get the results that we think we do. There is a great tendency on the part of all of us to overestimate the results we get and the capacity of students we are dealing with. What they need is a few simple principles thoroughly hammered in, and it takes continual hammering to make much of an impression.

I think we need to teach a few things, repeatedly illustrating them until they are thoroughly understood by the student. With that object in mind, I think that text-books ought generally to be provided, and illustrated in the class-room.

Professor Marston: I have recently had some experience in delivering a course of lectures to engineering students, the subject being "Engineering History." As you know, there is no text-book available treating this subject.

I had believed that it would be feasible to present the subject properly to a class of seniors if in the beginning they were given instruction as to the methods of taking lecture notes and if the lecturer should take pains to clearly outline his lectures and call attention to the most important points.

After examining the notebooks kept by the students, I became thoroughly convinced that the method of instruction by lectures should be abandoned as soon as it was possible to secure a passable text-book or to prepare the lectures in mimeographic form.

There is one possible advantage in connection with lecture notes taken by the student, however, which is that the instructor who reads them over will obtain from them a great amount of very surprising information regarding the subject he has been treating.

Professor Norris: The lecture is a necessary evil in a great many cases, and keeping in mind the principle that the student must be forced to work to get hold of a subject, the only excuse for the lecture is when it consists in giving instruction for performing some mental or mechanical processes.

Professor Jacoby: In connection with this paper, the speaker wishes to call the attention of the society to the advantages of having students deliver short lectures. This method has been adopted for a part of the course in Masonry and Foundations in the College of Civil Engineering of Cornell University. The best work on that course consists of files of engineering periodicals. The amount of space covered by such articles is very large. They are well illustrated as a rule and it seems desirable that students should become acquainted with these sources of information and by having the instructor classify and arrange the references beforehand, the students may be afforded sufficient time to study the references given to him, and to prepare illustrations on sheets of manila paper. With the aid of such illustrations, he can conveniently give the results of his study to the class. Experience shows that very excellent results can thus be secured.

There are so many good details published for most foundation structures that one student can be given one part of the structure for consideration and another a different part so that on a given day they can present a thorough discussion of the various details, while the instructor calls attention to the principles which are involved in the constructions illustrated. It is of service also to most students by helping them to give proper expression to their ideas, such power being recognized as of much value to every engineer.

It is important to emphasize the point that the course must be thoroughly worked out beforehand by the professor, arranging the topics very carefully and recording them upon cards, so that they may be conveniently assigned to the students.

PROFESSOR C. F. ALLEN: I have found that students who are given a chance to lecture to the class as Professor Jacoby suggests, often lecture as well as the instructor, and in this I have no intention of reflecting on the quality of the instructor's work, but rather to properly commend the work of the students.

PROFESSOR JACOBY: It is really interesting to see what splendid work can be done by some men, their reports being clear, systematic, and well arranged. In such cases the students usually applaud them heartily when they finish their reports.

PROFESSOR J. P. JACKSON: Professor Jacoby's remarks agree with the spirit of my paper and the other speakers, with the exception of Professor Merriman, are in fair accord with it. I have such a high regard for Professor Merriman's text-books, which I consider unusually good, and which, as he well knows, are absolutely incomparable with notes taken by students, that I think he must have intended to be humorous.

WHY NOT TEACH ABOUT MEN, THE MOST IMPORTANT AND DIFFICULT TOOLS AN ENGINEER USES?

BY JOHN F. HAYFORD,

Inspector of Geodetic Work and Chief of Computing Division, Coast and Geodetic Survey.

It is acknowledged at the outset that engineering courses are already crowded.

The proposed course, indicated in the question "Why not teach about men?" should be put into the curriculum of each college of engineering because the success of the engineer and therefore his usefulness to the community depends largely upon his knowledge of men; because the subject matter of the course cannot be secured quickly or easily by mere experience; because there are teachable fundamental principles to be followed in using men; and because of the high cultural value of such a course.

To say the success of an engineer depends largely upon his knowledge of men is no disparagement of his engineering knowledge. Engineering knowledge, that is, knowledge of the forces of nature and of the strength and properties of materials, is of course absolutely essential to the success of the engineer. It is his especial business to acquire and use this particular kind of knowledge. But he acquires and uses his engineering knowledge largely through other men. Therefore, the soundness of his engineering knowledge and the effectiveness with which he uses it depends largely upon his knowledge of men.

To have engineering knowledge does not in itself make an engineer successful or useful in the world. He must also have and use the power to pass that knowledge on to other men's minds. This convincing power on the part of a given man depends largely upon his understanding of the man to be convinced.

The engineer cannot escape dealing with men, as well as with materials and forces. You teach the student of engineering how to test materials, about the properties of materials, and the most effective way to use materials. Is it sensible, is it fair to the student of engineering, never to say a word to him about the best methods of determining a man's strength by watching his behavior under the many tests to which he is continually being subjected, never to say a word about the peculiar characteristics of various types of men, and never to call his attention to the relation of these peculiar characteristics to the most effective way of utilizing the services of these men?

But you may say, and with truth, that the strength of a man available to hold him in place and at his peculiar work under the petty and oft-repeated stresses of every day, and under the great stresses of extraordinary occasions, is a rather indefinite thing as compared with the strength of a piece of steel. The characteristics of each class of material are comparatively definite, and easily ascertained, as compared with the peculiar characteristics of different men. In short, you may say, man is so complex an organism, so difficult to understand, and the relations of his peculiarities to his efficiency are so indefinite that it is not important to teach our students about men. Each man must learn for himself, by experience, to understand other men. Each must depend largely upon intuition in this matter.

This is an easy, obvious conclusion. It is the usual conclusion, at which many men stop their thinking on the subject. Nevertheless, it is an incorrect conclusion, based upon a small part only of the available facts—not on all of them.

For example, it is also true that the output of different men, even in such work as routine computing by fixed methods, varies in the tenths, not simply in the hundredths; that in positions in which the use of judgment in regard to forces and materials is necessary, the variation in the output of different men varies still more; and that, in positions where judgment in regard to men must be exercised, of two men who are at first sight equals, the real output of one will frequently be twice or even ten times as great as the other. In fact the cases are not extremely rare in which the output of a man in an administrative position is less than zero, in which he is a positive damage to the organization of which he is a part. Because men are so extremely variable, even an approximate estimate of the capabilities of a given man is valuable, and it is important that the principles available for making even this approximate estimate should be recognized, studied, and taught to the student of engineering.

From the mere fact that it is extremely important that the engineer should understand men, it does not necessarily follow that the student of engineering should be taught about men.

If the subject matter of the proposed course can be quickly and easily gained by experience, the course should not be put into the curriculum.

There are many young engineers who are handicapped from the very start because of their ignorance of men, and who never rise above minor positions, because they never learn by experience that they must study men as well as things. Still worse, there are not infrequent cases in which an engineer rising because of unusual ability in other lines, in spite of ignorance of the ways of men, attains to an administrative position and in that position deals with men so clumsily and blindly that he partially paralyzes the very organization of which he should be the leader. The fact is that engineers, and others, as a rule, learn about men by experience very slowly and clumsily.

It is especially in the matter of dealing with men that many a man of forty or fifty sees clearly and with regret that if he could have known at thirty some of the things he later learned by bitter experience, his usefulness would have been much greater.

Is it not your duty to the young men of twenty who are in your charge as students to wake them up to the importance of studying men, and to pass on to them some of the concentrated experience of men of forty and fifty and sixty years of age, so that they in turn may learn by trial and practice between twenty and thirty what the men of regrets learned between thirty and fifty.

Teaching is the passing on of concentrated experience in the form of principles. Are there no principles applicable to the dealings of an engineer with the men with whom he will be brought into touch? I believe that there are.

So far as I know they have not been put into print by anyone in definite and concrete form. A proper text-book for the proposed course does not exist. Many successful administrators who are daily using the principles in question have never put them into words. Some of these men will tell you that they act upon intuition in judging men and in dealing with them.

This has been the situation in regard to many other engineer courses at an early stage in their history. There was a time when the great groups of principles now taught in the courses in masonry structures and foundations, bridges and other framed structures, hydraulics and water supply, did not exist in print except in a crude and exceedingly brief form. Then, the men who were successfully using these principles would have told you that they acted largely on intuition, based on experience.

The transition from that state of affairs to the present with its thoroughly organized and effective courses has come about largely through the slow but steady process of putting into words the principles which successful engineers used. In the main, it was the teacher who put the principles into words in clear, definite, teachable form—not the successful engineer. The teacher was forced to get the principles from a study of the practice of the engineer and from matter written by the engineer but not addressed to the student nor well adapted to his use.

So it must be with the proposed course. The professor who takes it up must expect to find little in print in the form in which he needs it, must look for his material to the practice of the successful administrators and to their writings on all sorts of topics. The teacher must expect the successful administrator to say that he acts largely on intuition in dealing with men.

Six months ago I happened to be talking over this subject with a man who is a good judge of men, and a successful administrator. He stated positively that he depended on intuition in judging men. A few weeks later I happened to be with him soon after he had finished studying a particular man with reference to appointing him to an important position. Because of my interest in so-called intuition used in judging men, I asked him to tell me about the afternoon he had spent with the man. Superficially, it appeared that the afternoon was merely a social one, in which for a considerable time the conversation was deliberately steered away from topics related to the work to be done in the vacant position. Examination, however, showed a deliberate method in the afternoon, and the application of reasonably definite principles to the study of this particular man. In the deliberate leading of the conversation away from the special work to be done, and in the careful study of the candidate's ideas on many subjects, there was a recognition of the principle that the most effective specialist is the man who keeps in good contact with the world at many points at the same time that he brings great pressure to bear in his one specialty.

There was in the afternoon a deliberate study of the motives of the candidate. The principle was tacitly recognized that a man's effectiveness in the long run depends largely upon the motive with which he works, the extent to which he works merely for cash, merely for personal success, merely because of a liking for a particular occupation, or mainly because of a deep desire to be useful in the world. While his motives were being studied the candidate was purposely led to talk about many other things than the main topic. This was a concrete application of the principle that a safer estimate of a man's real motives can be based upon indirect evidence than upon direct evidence.

In connection with the candidate's attitude toward the vacant position the time when he reached a decision was carefully noted. The ideal man does not decide until all the evidence is in his possession, or if he must decide on partial evidence, he makes his decision tentative. On the other hand, he makes his decision with reasonable promptness after the available evidence is before him.

So, too, the candidate's enthusiasm-capacity was carefully noted. A man who is filled with enthusiasm very quickly and for little cause has a small enthusiasm-capacity and will at some later time be emptied of his enthusiasm as quickly and by as small a cause.

This administrator said he tested men by intuition. A study of his own statements showed that his intuition was largely made up of principles, not clearly recognized as such by him, but nevertheless capable at least of being put approximately into words. The same principles may also be recognized in the actions of many other successful administrators.

Let me give an illustration of the way in which the principles which guide a good administrator may be found in his writings.

In his 1905 report, the president of the Carnegie Institution, referring to new projects for research, wrote: "Thorough deliberation in preparation and energetic patience in execution are indispensable to the highest success of such projects." A study of his acts shows clearly that it would be a correct quotation from his mind, though not from his pen, to say, "Thorough deliberation in preparation and energetic patience in execution are indispensable to the highest success of a man."

In connection with the proposed course on men, three lines of study should be associated with the main line, biography, the ethics of the profession of the engineer, and organization.

Biography should be studied as furnishing illustrations of the principles concerned in the main course.

The ethics of his profession is naturally to be taught the student in this connection because it deals with his relations to the men with whom he will be brought most closely into contact.

Organization should be studied, because its fundamental purpose is to use men effectively.

The average graduate's conception of the work of an administrator is very far from the fact. He believes that the way for a man in a high position to get a thing done is to *order* it done. Poor and indifferent administrators may do it that way. The successful administrators are men who act on the principle that their business is to administer unto those below them in the organization in three ways. First, by putting them into such places and under such conditions that they can do their best; second, by giving them the orders necessary to show what is expected of them; and, third, to enlist their *wills* as well as their bodies and minds in the work of the organization so that they will do their best. The first and third of these the average graduate has never seriously thought of. He sees in the administrative officer the man who orders. The successful administrator finds his time so thoroughly filled with the first and the third kinds of administration, with putting each man in the place and under the conditions most favorable to his effectiveness, and with enlisting in the service the will of the man, that orders fill but a small part of his horizon.

How much is done in the engineering course for which you are at least partly responsible to give the student a sensible view of this matter?

The proposed course will be a difficult one to teach. It requires a knowledge of men to teach about men, a knowledge of the unwritten principles of administration to teach administration, it requires rare tact to teach the true meaning of tact. But the great value of the outcome will abundantly reward those who resolutely apply "energetic patience" to the overcoming of the difficulties. The outcome will not be to make the average graduate at once a master of men. You do not expect even the graduate who has made a specialty of bridges to be at once an expert bridge designer.

The proposed course will have a high cultural value. Properly taught, it will tend to broaden a student's horizon and at the same time to make his thoughts deeper. It will broaden him because it will tend to make him see and pay attention to all phases of the men around him, to see and appreciate them as literary and artistic men as well as technical men, as men of feeling as well as men of thought, as incarnated motives as well as thinking and working machines. Properly taught, the course will tend to deepen the trend of the student's thought by tending to make him look back of the design of a structure to the ultimate purpose of the structure, to the man who is to use and be served by the structure, to the motives of the man, to the great onward movement in which the particular man and his motive are but a part.

The course will tend to develop the best in the student by leading him to the thoughtful study of other men. The man who really understands other men understands himself. The man who controls other men controls himself. The man who develops the best that is in the men around him, by an unconscious process develops the best in himself. The highest type of cultured man is represented by the man who, in striving to understand and help his fellow men, has used all his powers, and so has developed them all.

In the old, classical, college curriculum, the subject matters were largely man, his language, and his thoughts. In stating the purpose of the teaching, emphasis was laid on the culture to be gained by the student. In colleges of engineering, on the other hand, the subject matters are materials and the laws of nature, and in defining the purpose of the teaching the emphasis has been laid upon the word useful rather than upon the word culture—a decided improvement. The attempt has been to give the student a useful knowledge of *things,* a knowledge that will be directly useful to him, and make him useful to the world. In swinging away from the old curriculum, the colleges of engineering have gone too far in dropping man and his ways from the subject matter. Put this subject matter back into the curriculum, but, in treating it, keep the emphasis on the word "useful." Knowledge of men which is to be useful must be based upon clear, accurate and honest thinking. Teach about man with that motive and in that way and real culture will necessarily be one of the results.

DISCUSSION.

PROFESSOR ABBOTT: The teaching about men is an important phase of engineering education. For the efficient carrying forward of any engineering enterprise, loyal and harmonious cooperation must be obtained. This cannot be done by putting the wrong man in the place to be filled, or by hampering the right man so that he cannot do the work desired of him. Mistakes made by displacing men are expensive whether the man prove unequal to the task or an able man be placed in a position below his capabilities. Granted that a man be in the position best suited to his capabilities, there is another condition requisite for his highest efficiency, and that is an esprit de corps. While intuition may guide many in their management of men, yet there is no doubt that a person who intelligently understands the fundamental principles would manage more efficiently.

PROFESSOR D. C. JACKSON: The stirring of the executive ability and the training of the administrative capacity of a young man, we recognize as being the most difficult things we can attempt to do in the engineering college. The administrative capacity has to do with the management of men, instead of the management of materials, which is the usual object of an engineering college course. I doubt whether very much in the way of true administrative processes can be successfully taught in a fixed college course, however well the college is organized. That is not the way such a training comes.

It has been impressed upon me for many years that this thing of engineering instruction is a matter of research rather than a matter of fixed practice, and will remain so for a great many years. Our present practice has come upon us by degrees. Dean Turneaure has been doing a lot of good for the Wisconsin students by a few lectures that he has been giving to freshmen and sophomores. These are in the nature of personal talks. I do not know just how many he gives each year, but there are several. These talks are in regard to the ideals and the proper ambitions of the engineer, what he should like to be. That kind of talks should come to the young men as early as the sophomore year, and cannot very well be included in the formal course. The effect which is desired must come from inspiration and reflection, and not as a matter of formal study, and right lectures from men of the right character will do a great deal. But, at the best, there are a considerable number of men in college classes whose mental springs are not to be deeply affected by any ordinary methods of procedure.

I know that some of my colleagues have done with the higher class students as I have done. They have talked to their students. I have been very intimate with the graduating class for years in one of the courses in my college, and I have not hesitated in the class room to point out to them their own faults, and the faults of young men generally. These students hear a good deal about ethics and administrative matters and proper executive methods during the course of their senior year. Perhaps some may feel that I am sacrificing matters I am supposed to teach for the purpose of giving these talks. I think it has brought good results. Another thing has been to ask one or two men in the faculty who have had extended experience in employing men to give an hour's talk each, and that has been of advantage to the young men. The fact that these talks come from different men, and are more or less repetitions, adds much to the force with which they strike the hearers. The whole effect is good.

The colleges are doing much in this direction, but they must do it by the way of inspiration and suggestion. It seems to me that the colleges cannot do these things by fixed courses. For instance, we want to put into our men's minds the importance of getting along with people successfully by tactful processes of the right kind; we must teach this by tact and inspiration. It takes a lot of tact to do it. I doubt whether a regular fixed course on administration can be handled so as to produce the desired result; but this question of engineering instruction is a matter of research; perhaps I may change my mind in the next decade.

Professor Brackett: Can any form of student organization assist in developing this most desirable quality?

Professor Marvin: Entirely different from this last point, present practice demands graduation from the good technical schools on the part of young people who are seeking positions. That throws the responsibility back upon the school and one of the modifications of engineering instruction must result in better pay of teachers, especially among the younger teachers. It is one of the problems that all of the schools have to meet every year, to find the right kind of young people to place in the lowest grades of instructors. The salaries offered are not high enough to induce the best kind of people to apply or to keep them long when appointed. Both the public and the financial administrators of our colleges need education on this point. Freshmen need wise and experienced teachers as much or more than do juniors and seniors, yet it is too commonly the practice to put them in charge of those of inexperience.

Professor Magruder: We have heard a great deal of the additions which should be made to the curricula of our colleges in the way of courses in business training, law and philosophy. At previous meetings we have heard much of the same kind. In technical and trade papers, we, mechanical engineers, have been told that we should give courses in the details of steam piping, ventilation, heating and refrigeration, and occasionally we are almost held up to scorn and ridicule. I have yet to learn of a helpful suggestion as to what we are to eliminate either in whole or in part, or what modifications we can make in our present courses under existing conditions. With most of us we cannot increase the requirements for admission, as we are forced to get our supply of students from the graduates of our best high schools. At present there is little use in talking about making the course five years in length; and there is no way known by which we can put more than 365 days of 24 hours each into a year, unless it is a leap year. Have we not reached the limit of the cramming process and should we not keep in mind most clearly and forcibly that our chief business as engineering educators is to educate our students and to train them in the everlasting principles of the engineering profession and to leave the furbelows and details to the future? We cannot do it all in four years. We should leave something for the foremen, superintendents, chief engineers, general managers, who come after us; and we should strive to create in the mind of the student a desire for more education rather than a feeling of surfeiture.

Mr. Hayford: Taking the last speaker's statement in its extreme form it would seem to indicate that first come, first served, is the rule to follow; or things which are in the prescribed course first stay in. The question ought to be held open permanently, whether some other things should be put in and something else taken out. I simply want to be in protest against closing this question. If what is in must stay in, there is not room for anything else. The situation is that what is in and proven for years to be good, is probably the best. The man who proposes something else ought not be ruled out on the start. But the burden of proof should be put upon him.

PROFESSOR C. F. ALLEN: Slightly on the other side, and in a little different form, somewhat in agreement with Professor Magruder, is it not true that the answer then must be—if advance in practice brings so many things before us I then must give up the idea of trying to meet these details, and settle down to the basis that modifications must be backwards in the direction of simplicity? A great multitude of good things forms an argument against reaching out too far. If it is impossible to reach all, then attend to what you ought to, the substantial principles. It will be an opportunity for what Mr. Hayford wants, but the work should be of the basic sort. Most of our engineering schools are already going too far and the argument is towards simplicity.

PROFESSOR R. C. CARPENTER: I believe that all of the college courses should be modified at quite frequent intervals to suit outside requirements; when we learn from our graduates who are out in competition with other engineers that the training which they had was deficient in some particular thing, we look around to see what can be done in our course of instruction to remedy it. I believe such tests are applied in all engineering courses. We have been studying over the question of amendments to our course for the last three years nearly constantly. We have had an opportunity to make some changes due to advancement of our entrance requirements, which has enabled us to require the high school to teach some subjects heretofore taught in college. By having the language work done in the high school we have gained a good part of a year and are able to cover the broad technical studies by the end of the junior year, which leaves practically all of the senior year for advanced, special, and elective studies. This has also permitted us to put into the last year several elective technical courses which we had not taught heretofore. We feel that these changes will result in an improvement over our previous work and that our men will be better fitted than before for active engineering business. I append a copy of the course as recently modified.

SIBLEY COLLEGE, COURSES IN MECHANICAL ENGINEERING LEADING TO THE DEGREE OF MECHANICAL ENGINEER.

All courses taught in Sibley College of Mechanical Engineering and Mechanic Arts are identical for the freshman and sophomore years.

Regular Course.

The letters and figures relate to the departments and courses in Sibley College.

Freshman Year.	No. of Course.	1st Term.	2d Term.
Analytic Geometry	2	5 or 5	0 or 0
Differential Calculus	2	0 or 0	2 or 2
Integral Calculus	2	0 or 0	3 or 3
Chemistry	C. 1	6 or 0	0 or 6
Physics	P. 1	0 or 4	4 or 0
Physics	P. 5	0 or 2	2 or 0
Descriptive Geometry	C.E. 9	2 or 0	0 or 2
Drawing	M.D. 1	3 or 0	0 or 3
Patternmaking	M.A. 1	0 or 4	4 or 0
Shop methods	M.A. 2	0 or 1	1 or 0
Military Drill		1 or 1	1 or 1

Sophomore Year.	No. of Course.	1st Term.	2d Term.
Mechanics of Engineering	C.E. 20	5 or 5	5 or 5
Physical Laboratory	8 and 14	3 or 3	3 or 3
Chemistry	6	5 or 0	0 or 5
Kinematics	M.D. 6	0 or 0	2 or 2
Drawing	M.D. 5	3 or 3	3 or 3
Materials	X.E. 5	2 or 2	0 or 0
Foundry	M.A. 5	0 or 2	2 or 0
Forge	M.A. 6	0 or 2	2 or 0

In addition to the above three hours per week of either Military Drill or Physical Culture must be taken.

Courses for the Junior Year.

The courses in Electrical Engineering, in Railway Mechanical Engineering, in Mining Mechanical Engineering, in Chemical Mechanical Engineering and in Physical Mechanical Engineering are all identical with the Regular Course throughout the *junior year*. The courses in Naval Architecture and Marine Engineering are different from the Regular Course as shown by the note following the schedule of studies.

Regular Course.	No. of Course.	1st Term.	2d Term.
Steam Machinery	P.E. 10	4 or 0	0 or 4
Electrical Engineering Laboratory	E.X.E. 10	2–2	2–2
Electrical Machinery	E.E. 11 and 10	0–4	4–0
Machine Design			
(*a*) Lectures and recitations	M.D. 16	3–3	3–3
(*b*) Drawing	M.D. 10	2–2	2–2
Mechanical Laboratory	X.E. 11	3–3	3–3
Machine Work	M.A. 10	2–2	2–2
Principles of Manufacturing	M.A. 11	2–2	0–0
Hydraulics	C.E.	0 or 0	2 or 2

Courses for the Senior Year.

Senior Year. All Courses excepting Naval Architecture (D).	No. of Course.	1st Term.	2d Term.
Steam Engineering	P.E. 20	3	0
Mechanical Laboratory	X.E. 20	3	3
Electrical Laboratory	E.X.E. 28 or 29	3 or 0	0 or 3
Thesis or substitute elective studies as approved by Sibley Faculty (maximum)		0	8

In addition to the above each student in his Senior year must complete *one* of the following groups of studies A—I (except D):

A. Mechanical Engineering.

	No. of Course.	1st Term.	2d Term.
Steam Machinery Design	P.E. 21	3	3
Designing and Drawing	P.E. 22	3	3
Design Elective		0	0
Elective (see list)		2 or 6	3 or 0

B. Mechanical Engineering.

	No. of Course.	1st Term.	2d Term.
Machinery and Machine Tools	M.D. 22	2	1
Designing and Drawing	M.D. 23	3	3
Design Elective		0	2
Elective (see list)		4 or 7	3 or 0

Elective Studies in Mech. Engineering.	No. of Course.	1st Term.	2d Term.
Pumping Machinery	P.E. 24	0	3
Power Plant Installation	X.E. 21	1	0
Motor Car Construction	X.E. 26	0	1
Internal Combustion Motors	X.E. 24	3	0
Internal Combustion Motor Design	P.E. 25	0	2
Engine Handling	X.E. 23	0	1
Engineering Research	X.E. 22	3	3
Physical, Chemical or Electrical Laboratory		3	0
Heating and Ventilating	X.E. 25	0	2
Resistance and Propulsion of Ships	N.A. 11	0	2
Experimental Tank	N.X.E. 27	0	1
Motor-boat Design	N.A. 23	0	1
Refrigerating Machinery	X.E. 30	0	1
Steam Boiler Design	P.E. 23	0	2
Steam Turbines	MAR.E. 21	2	0

C. Electrical Engineering.

	No. of Course.	1st Term.	2d Term.
Electrical Engineering Laboratory	E.X.E. 28	0 or 3	3 or 0
Electrical Engineering Lab. Rec.	E.X.E. 28	1	1
Electrical Engineering	E.E. 20	2	2
Electrical Engineering	E.E. 21	2	1
Elective		3	1

D. Naval Architecture.

	No. of Course.	1st Term.	2d Term.
Steam Engineering	P.E. 20	3	0
Mechanical Laboratory	X.E. 20	3	0
Electrical Engineering Laboratory	E.X.E. 28	3	0
Ship Design and Construction	N.A. 20	3	4

Naval Architecture	N.A. 21	2	2
Propelling Machinery and Equipment	MAR.E. 20	2	0
Steam Turbines	MAR.E. 21	0	2
Experimental Tank	N.X.E. 27	1	1
Specifications, Contracts and Cost Systems	N.A. 22	0	1
Electives (including Thesis)			8

E. Marine Engineering.

	No. of Course.	1st Term.	2d Term.
Propelling Machinery and Equipment	MAR.E. 20	6	4
Steam Turbines	MAR.E. 21	2	0
Naval Architecture	N.A. 20 and 21	1	1
Naval Architecture	N.A. 11	0	2
Experimental Tank	N.X.E. 27	0	1
Specifications, Contracts and Cost Systems	N.A. 22	0	1
Thesis or other Electives	MAR.E. 22	0	7

F. Railway Mechanical Engineering.

	No. of Course.	1st Term.	2d Term.
Railway Machinery	R. 20	4	4
Designing	R. 21	4	0
Railway Club (elective 2d term)	R. 22	1	(1)
Locomotive Testing (elective)	R. 23	(1)	0
Electric Railways	E.E. 25	0	2
Electives: Lectures, Designing	R. 30, 31	0	3

G. Applied Physics.

	No. of Course.	1st Term.	2d Term.
Alternating Currents	Physics 33	2	0
Electrical Measurements	Physics 34	3	3
Physics of Trans. of Intelligence	Physics 41	1	0
Elective as approved by Sibley Faculty		3	3

H. Chemical Engineering.

	1st Term.	2d Term.
Courses as arranged for with Department of Chemistry	9	6

I. Mining Engineering.

	1st Term.	2d Term.
Geology and Mineralogy	4	3
Chemistry and Metallurgy	5	3

PROFESSOR MARSTON: During the past year the school with which I am connected has been thoroughly revising its engineering courses. We had a special committee of the faculty prepare statistics of the engineering courses of a number of the leading schools of the country, tabulating the essential features. We were interested to find that these schools were generally in accordance as to all the essential features of their engineering courses.

In studying the possibility of improving our engineering courses we found it very difficult to make any radical changes which would probably be improvements. However, in addition to rearranging the course so as to secure uniformity as to the number of credit hours in the different semesters, and uniformity to such extent between the different engineering courses as seemed feasible, we did introduce two or three changes of a general nature.

As the number of our engineering students has very rapidly increased during the last few years, we have experienced a difficulty in securing the personal contact between the students and the faculty which with smaller numbers of students was so great an element in our educational work. The loss of this personal acquaintance must in some way be made up, and we are trying the experiment of introducing technical lectures throughout the freshman and sophomore years, delivered by the different members of the faculty. We are adopting this name of "technical lecture" for want of a better. They are, to a large extent, heart to heart talks in which the instructor or professor gives the student many ideas and suggestions connected with the engineering profession and with life in general.

In the junior and senior years the engineering seminar, in which the student becomes himself the lecturer, takes the place of the technical lectures of the freshman and sophomore years to which I have just referred. It is the intention to conduct these seminars as nearly on the basis of an engineering club as possible.

We find in revising our engineering courses that there has come to be much demand for instruction which will help to fit men better along business lines in engineering. We have introduced a course of instruction in specifications and contracts, given by one of the professors who is a practising engineer, to partially meet this want.

We also feel it in the air that the tendency in all engineering courses must be to broaden out the work, not merely by introducing general culture studies, for which there is, in fact, little room, but by broadening the technical instruction itself. We see no reason why a study of engineering history might not have as much cultural value as the study of general history, nor why the study of railway administration might not be as valuable training as the study of some textbook on political economy.

PROFESSOR JACOBY: There is one point, not as important as some others, which the speaker thinks should be considered in view of the pressure which is brought to bear on the introduction of new work. It is necessary to emphasize the fact that the amount of material our best students can assimilate is frequently overestimated. During the past year an effort has been made in the college represented by the speaker to reduce the hours of work. It should always be kept in mind that there is a great deal of study to be done by our graduates after they go out into practice and it is of considerable service to them, while lectures are delivered on a particular course, to indicate directions in which further study may be profitably pursued, giving suitable reference for the purpose. The young graduate may be able to get some help in this direction from those with whom he is associated professionally, but generally not as much as he should. In the preparation of text-books authors should also bear in mind the value of giving references to other similar works, to encyclopedia, transactions, engineering periodicals, etc., so that the student can follow up any subject advantageously.

PROFESSOR WALDO: One subject has been touched upon which is of vital importance to us all and that is the cultivation of English. If, in some way, we could make our technical students masters of pure idiomatic English, I feel quite sure that the demand for the A.B. course, as underlying the technical course, would very greatly disappear. Such a command should come from proper training at home, in the grades and in the live languages.

PROFESSOR R. C. CARPENTER: I believe that our students do not receive sufficient practice in the use of English. We have been trying the last four or five years to remedy this deficiency in our course of instruction by having students write full laboratory reports, which are corrected for English composition as well as engineering matters. All students are required to write quite an extensive report at least once a week; that has given us some opportunities for extending our course in English, which we are trying to take advantage of.

A MEMBER: It is my custom in all examinations in technical subjects to reserve twenty per cent. of grading to completeness of the answer, systematic arranging of the matter, capitalization, handwriting and spelling.

Professor Merriman: As one of the members of the committee which presented the report to "Consider the Publication of a Biography of the Engineering Profession," I wish to say that it was prepared with considerable deliberation and we believe the recommendations to be sound. It is a matter of regret that the program of this meeting does not contain any papers of a historical character. It has been said that some professors give to their classes lectures on the history of engineering. If these lectures could be given at our annual meetings or be printed in our proceedings, it would be of interest and value to us all. In this connection I note that last week, at the annual meeting of the American Society for Testing Materials, Professor Lanza read a paper containing accounts of the life and work of several deceased investigators whose labors on the strength and mechanics of materials were of special value to the engineering profession. This paper is a valuable contribution to the history of American Engineering, and it is to be hoped that similar ones on other lines of work may be prepared by our members.

Professor C. F. Allen: Those of us who have been present at most of the meetings of the society will remember that occasionally a pessimistic view has been advanced that the subjects have been threshed over pretty generally and all the ground has been covered so that on the whole this society was not worth while. Whoever made such a remark did not anticipate the presentation of a paper of this sort. It covers new ground and I do not see how we can readily escape the conclusion that this paper presents to us some views that we cannot afford to push aside. It seems to me that we must do something in some way in recognition of what this paper points out as our duty. I take it for granted that it will give us a lot of trouble if we try to follow it out and I do not know what success we will have in starting in with it. It seems to me that it is right. It occurs to me that the successful teacher whose duty and whose habit is to study character, to study men, is to that extent in a position to make progress further in the direction of formulating some rules as suggested. The fact that in teaching it is absolutely necessary that we should make the study of men before us is a point of advantage, and certainly commends itself to me.

I have found myself thinking that the author of this paper, while pointing out the fact that the man who studies men is developing himself still further for his regular business duties, the author of this paper failed to make the point that he is preparing himself also for the most useful citizenship, a point certainly to be included. The man who is able to administer laws and control the men with whom he is in business contact ought to be most successful in his social and political relations, which are all duties which every educated man ought to assume.

PROFESSOR R. C. CARPENTER: I believe all of us have experienced many of the disadvantages which have been referred to and I think we all feel the importance of knowing our men and of having students know men. It struck me, however, that many of the things referred to are things which can come better after he has left college than while in college. I think we might make a great many mistakes and I doubt if men would be more useful with the course of teaching suggested than with that in force at the present time. The success of the young men in outside work depends upon ability to handle men and to get along with them, and I believe in pointing out administrative methods. An engineering college has but a limited time and unless the men are better trained before they come, it must confine itself to engineering matters. If we should undertake to teach the many outside things we should be taking up the time that the men could not afford to spare, and we could not fit him for the duties which as an engineer he is certainly to find awaiting him.

I do not question the importance of the proposed courses, but I do doubt the wisdom of cutting out any of our present studies for a course of training as proposed, which I believe can be better obtained out than in college.

PROFESSOR TURNEAURE: This paper formulates, I believe, a little more accurately than has heretofore been done, some things that are apparently "in the air." They have been touched upon at this meeting under the head of philosophy and have been mentioned by several who have discussed various papers. The education of a young man in the knowledge of his fellows and in his attitude toward life generally is undoubtedly a very important thing. The only question is how this can best be done. Some prominent college presidents are evidently attempting to partially solve this problem through the establishing of the dormitory system. The idea underlying this proposition is that the young man will become better acquainted with his fellows under this system than under the more common system of separate boarding houses. This intimate contact of students is certainly a valuable aid in inculcating this knowledge of men about which we are talking. It is possible that we will, in the near future, formulate some course of study which will accomplish these results, but we do not feel at all sure of this. I am not very enthusiastic over the idea of giving the freshmen or sophomores a prescribed course in logic, or philosophy, or in the handling of men, particularly if such a course is given by a professor with only limited experience in the conduct of engineering work. I believe that the most that can be accomplished at the present time is by the introduction of such incidental instruction and suggestions as mentioned by Professor Marvin. This method has been considered to quite an extent in the University of Wisconsin during the past year. One of our professors who has had a large practical experience gives a course in contracts, and utilizes this course in much the same way as noted by Professor Marvin. His experience in this direction has been very satisfactory and has led us to consider quite seriously whether this particular course should not be enlarged for the purpose of introducing more good sort of instruction.

PROFESSOR MCNAIR: I have been very much interested in this paper. Any one who has been in close touch with graduates who have gone out from his school in the last ten years must recognize the pertinency of its subject. Whether he agrees with the conclusion is another matter. In the Michigan College of Mines, I suppose the author would agree that we are doing something of what he wishes. In two of our chief lines of work we are already giving courses in organization which deal to a considerable extent with administration, although I must say that the stress is put more on machinery of administration than what might be termed its philosophy.

Something of this sort is in the air. If you talk with men out in practice as I have done in the last three or four years you will find a good many of them wishing they could have been given some insight into the handling of men before leaving college. If you ask those men what the college can do, you will find that they are not in a position to formulate very much. Several of our own graduates, and many others agree with them, have in the last two years gone this far. They have said, "I think you might have pointed out to me some of the mistakes which I was liable to make, some of the mistakes which I did make in my first contact with men." One of these men, out ten years, gave me an incident, occurring in his first two or three years, in which he had failed to handle men. He studied his fellows in college and got along with them well. Out in practice his first contact with men where he was compelled to influence them was with a gang of laborers with which he was set to accomplish a certain piece of work. He failed so completely that he did not stay long with that particular employer. He went into other work, avoiding responsibility for labor until he learned how other men handled laborers. He is now a successful administrator in charge of a large force of men. He thinks we might have saved him his first failure by impressing him with the necessity of studying laborers and especially the methods of successful foremen beginning with his first opportunity, a necessity appreciated by him only when he found laborers could not be handled as could men of his own kind.

I am willing to admit that we can do something to help our graduates avoid the mistakes that they are most likely to fall into when they first start out. As to putting in a course, I think the best work can at present be done in connection with courses which are already given by men who have had experience in the world and know what the world is like.

PROFESSOR LANDRETH: From the standpoint of engineering education, this paper presents the most important topic discussed for a number of years. I accept the assumption made by the author that progress cannot be made without criticism of our work and asking whether by changing of curriculum we can improve conditions. The idea that the curriculum exists, therefore it is the best, is the most fatal mistake that we can take. How can we prevent this result? The desired ends can be obtained, it seems to me, either by substitution or extension in the present curriculum. I am not sure that a remedy will be found in either of these. It may be possible to extend the course from four to five or possibly six years. There are some factors that are going to make that unavoidable in the future. We appreciate the necessity for a great amount of training in our engineers. I am in sympathy with more culture. I think we can accomplish those purposes without spoiling the engineers. If we wait until the man has completed the engineering course, we have gone past the point to lay the foundations of engineering, in addition to methods of thought which are essential, which are not inculcated if we begin too late. On the other hand, we cannot do without the training. The man is to be congratulated who can determine in advance whether he can spend five or six years in the correlation of his education, so that his training in culture can begin with his training in engineering. That gives opportunity for doing special work on topics which are pertinent to the work of administrative training.

I do not believe in the elective system without control. The electives are liable to be chosen badly by students on account of their want of knowledge of relations of one topic to another. If we arrange a series of optional subjects, then he is in less danger of making mistakes by selection.

At Union College we follow this latter idea. At the end of the first year students are allowed to make a selection from the options of the course. We have omitted from the course those subjects which are not liable to be needed, and in place thereof we give more work in history, sociology, financial operations and administration.

I am heartily in sympathy with the author of the paper in the feeling that these principles can be formulated in definite form because I know they can. It is simply the difficulty we all go through. We know by experience that science evolves from facts. In a successful course in organization we have not yet got to the facts.

PROFESSOR SWAIN: This paper is a very suggestive and interesting one. I think its principal value to us is in making us see more clearly that we ought to be something more than mere teachers of our special subjects. We ought to stand before our students, having for our duty to enlarge their minds, point out lessons from our own experiences, and to help them to grow both mentally and morally. I have been accustomed to interrupt my lectures at any suitable point to bring in experiences, or anything that would point a moral.

A good deal has been said in regard to the fact that some graduates come back after fifteen or twenty years and ask why we did not do something which would have prevented them from making mistakes, or why we did not include some other subjects in the course. The fact is that the men who make such remarks would have failed to appreciate the matter in their student days; one of the principal problems before the teacher is to make the student wake up and realize. In this we do not often succeed. I take my last lecture hour and devote it to the very things Mr. Hayford has referred to; that is a short time, but it is not the only time given to the subject during my course. I tell my students about the ethics of engineering, about the relations they bear to their employers, their attitude toward the man to whom they have applied for a position and during the time they are waiting to hear from him, and such topics. Last year it was only twenty-four hours after one of these lectures that one of these students broke, in a shameful way, one of the very rules I had endeavored to impress upon his mind; and he received a very pointed reprimand from an engineer to whom he had applied for a position. It is unfortunately true in regard to the philosophy of life that most of its precepts can only be learned by dear experience in the case of most men; and, while the subject, in a way, can be taught at school, it makes but little impression. After making mistakes ourselves, and feeling the loss it occasions, then we really learn the lesson. I am a great believer in the discipline of experience. Nevertheless, I think a teacher may take advantage in a course of instruction of suitable points where he can develop moral lessons which will perhaps make some impression, but I do not think that at present we are prepared to give a course in such a subject in our engineering schools.

PROFESSOR MARVIN: There are two or three points which I would like to touch upon in this connection.

When the average young man thinks that he is being lectured to in a premeditated sort of way, he becomes somewhat resistant. He is averse to being advised. A gentleman of my acquaintance had a boy who would not do as he advised and desired. When remonstrated with for treating his father's wisdom and experience so lightly, the young fellow said that he just had to find out things for himself.

There are two points of attack that an instructor may find vulnerable. The young men that we have to do with, as a whole, are sound in mind and heart and when a direct appeal is made to their higher sense of what is just and right and fit, one is able to touch a responsive chord. The other point of contact makes use of self interest and is one that appeals to every young imagination looking forward to a career. A peering into the future to catch a glimpse of themselves as real workers in the world, to see what they are going to be and do, what power and place or station they are to hold—these things interest young men strongly. One might be called the ideal method of attack, the other the commercial; but they are both legitimate and both useful in yielding results, whether dealing with an individual case or with a class, provided that there exists a close contact between the mind of the teacher and that of the pupil and some personal power and magnetism on the part of the former.

In my own experience, I have found that the most profitable medium through which to influence a class along these lines we are discussing lies in a course in contracts and specifications. In a course covering daily work for ten weeks, the young men get a fair insight into contract law, some knowledge of the forms of specifications and a respect for the skill and experience which lies back of their writing. But they get much more than the technical side of the subject, for there are constantly coming up in class questions of morals, of the right and wrong of things; matters affecting their own relations to society and to their fellows; matters of professional ethics and conduct. Placed as it is, near the close of their college life, when the next step is into the midst of the very things that are matters of discussion in the class, students become vitally interested and perhaps for the first time, with some, they realize that after all right thinking and doing has something to do with real life, that perfect integrity is the real nest-egg of their professional capital.

In some places this course is given by a lawyer, but, in my judgment, while the lawyer undoubtedly would give the sounder technical instruction, it is not the lawyer's point of view that will yield the best general results, unless he be specially qualified through a wide knowledge of engineering practice and a willingness to deal simply with general principles rather than technical details, and is also glad to use the opportunity to force home those things, so easily and appropriately introduced, which make for stronger and better manhood.

PROFESSOR WALDO: Could not the subject under discussion be profitably enlarged to include several other things? The duty of our graduate to the engineer or corporation that employs him? His duty to the public? His duty when loyalty to his employer and public duty conflict? Is he ever justified in putting defective workmanship or material into his structure for the immoral profit of his employer? Cannot our students be fortified in right acting when crises like these occur in their graduate experience?

Professor J. P. Jackson: The results of this discussion may suitably be summarized thus: If the deans of the schools of engineering in the United States should be given full authority to personally employ all the instructors under their direction and should, when making the contracts, let it be understood that such instructors are not only to teach machine design, dynamo machinery, etc., but also to teach character, purity of morals, and more particularly the philosophy of the Good Samaritan, their graduates not only will be able to deal with men, but will be able to do so in a way to do the best and highest good.

Professor C. F. Allen: I do not feel at all sure that a special course should be given in this subject, but I do believe that the student's mind should be called very distinctly and directly to the fact that he must study men as well as other materials that he has to do with. The presentation of two or three lectures or even one would do a great deal to call attention of the students to that phase of his work. It is at present my intention with Professor Swain's approval to read to my class Mr. Hayford's paper as a good start in the way of calling attention to the students to the importance of the study of men; my impression is that after reading his paper I shall be a little ashamed to drop the matter there and not do anything more with it. A short course of two or three lectures is likely to come later.

Professor Brackett: To give the students of advanced classes the actual experiences of recent graduates seems to me a very effective method of impressing upon the individuals what will be expected of them when they begin practical work. A definite statement of the successes and failures of a man, who is probably well known by many of those addressed, even though his name is not presented, seems to most persons much more real than what may happen in the future to some one of their number.

We believe it a good plan to keep in close contact with our recent graduates; to get them to write us freely and fully about their early experiences. Then we use these experiences, stated anonymously of course, to both warn and encourage our undergraduates.

PROFESSOR C. M. WOODWARD: I was delighted with the paper. I enjoyed the discussion. I have always felt that one's duty as an instructor was not limited by the subject in the catalogue. He should always be a leader and I believe that the suggestions of to-day we shall carry home with profit. In Washington University it is my custom to give a short address to freshmen the day they enter. I talk to them about their life in the institution and their relations to each other. I try to put them in sympathetic attitude with their work. I give a course, one every semester, eight lectures in all, gradually talking along in the work they are doing and in the responsibility that they are beginning to carry, and end up with the final talk which may cover two hours, if necessary, in telling them the whole story of their relations with the men around them, under them and over them, and their duties to the public. I think it is an immensely important subject. This is the humanities side of our course. This gives an opportunity to get after the men; to train them with regard to proper relations with other men.

It is a fine thing in education; no system is complete without it.

Mr. Hayford: In closing I will touch upon a few points only.

I am delighted to see in this discussion signs that indicate that teaching of this kind is already in progress, and still more delighted to see that more will be done in the future.

In regard to one thing that Professor Carpenter said—looking at the matter from the point of view of one who is brought into contact with young men—I disagree with the proposition that the man who is to handle men should begin studying them after he is out of college. It is a costly process to learn from your own experiences rather than from the experience of others. The training referred to makes politicians out of men in college. It does not appeal to me as being of very much value, because it is mere play-training with little resemblance to outside conditions.

Professor McNair indicated that there are certain class of mistakes men make in the first three or four years. The warning of young men against these mistakes is a good thing. It is a better thing then to add to that warning reasons why these mistakes arose. You can make these warnings more effective if you show the reasons for them. A broad statement of the case to be given to students is better than the specific warning against mistakes.

Professor Swain's talking to that student did not prevent his making the mistake. But the important question is whether that student appreciated the reprimand from the man better than he otherwise would because the professor had talked with him beforehand.

I agree that it is not necessary to have a separate and distinct course. You may bring in this teaching along with other things. I appreciate the force of the suggestion that as soon as you lecture to a man on anything connected with morals, his resistance increases. You must perhaps teach this subject in connection with something else. I see the necessity for the teaching clearly, it is for you to find out how to teach it. I do not claim to have a clear insight into the proper method.

As Professor Jackson said, to teach tact is perhaps the most difficult task a teacher can put before himself. To develop administrative ability after a man gets out is also an extremely difficult task.

When you approach any other line of teaching, you approach it directly. What is there peculiar about this particular line that makes it certain that when you attack it, you get at it indirectly. Perhaps that is the right way, but I am not yet convinced.

THE WORK IN THE MECHANICAL AND ELECTRICAL LABORATORIES OF SIBLEY COLLEGE.

BY R. C. CARPENTER,

Professor of Experimental Engineering, Cornell University.

The principal excuse for this paper is the location of the meeting of the Society for the year 1906 at Cornell University. This paper is intended to point out the general plan of organization and to describe the methods of instruction which apply to the Sibley College laboratories.

As a preface, it may be stated that the work in the laboratories is given a very prominent place in the course of study which has been adopted. In addition to the service for research and investigation, it is expected that the laboratories will in a large measure train the undergraduates so as to fit them better for investigation and research and for practical engineering work after graduation. As the amount of time which each student can possibly devote to this work is limited, a systematic scheme has been gradually evolved as the result of experience for conducting these experiments, for taking a certain number of observations in a limited time, and of writing out a full report of the experiment under the prescribed conditions and rules.

No argument will be advanced as to the value of this system as compared with some other way of doing the same thing, as it is extremely possible that under different circumstances and conditions very different methods would give better results. It is intended to point out merely the method here used of carrying on the laboratory work rather than to offer arguments as to the desirability of this or some other scheme.

Laboratory Organization.—It may be interesting first to consider the organization which has charge of the laboratory work. The laboratories are in the general charge of the department of experimental engineering, which also gives instruction in certain practical studies which the members of the department are specially well adapted to carry, but its energies are devoted principally to the laboratory. The Sibley College laboratory has two branches, one mechanical, the other electrical. The laboratory organization is in the general charge of the professor of experimental engineering, each department being in special charge of an assistant professor of experimental engineering, with a sufficient number of instructors to give the necessary instruction to the students.

Nature of the Laboratory Work.—In each laboratory the work is of two kinds which I will designate as, first, required undergraduate work, and, second, research and investigation. The required undergraduate work is taken by the students in the junior and senior years and is intended to train them in the application of theoretical principles, in habits of accurate observation, in methods of handling and operating machines, in drawing conclusions from experimental data, and in the writing of reports in good English. The field which it is intended to cover is a very broad one, extending over methods of testing materials and of machines in nearly every branch of mechanical and electrical engineering.

During the past year about 500 men registered for the work in the mechanical laboratory and about 250 in the electrical laboratory. These relative numbers will remain about the same next year, after which the registration will become equal in the two laboratories due to the change of course which was made about a year ago.

In order to give the undergraduates as much laboratory practice as possible in the time which they have at their command, a series of experiments have been selected which are arranged in groups. All of the experiments in any one group are selected so as to be as nearly as possible equal, in the point of preparation required, and are taught simultaneously during the laboratory period. The students performing the experiments work in groups of two or three, the members of each group working together during an entire term and being assigned as a unit. When the experiment is of such a nature as to require more observers than would be found in one group, two or more groups may be combined to give the requisite number.

Each group of students is required to work up completely and fully the data taken during their experiment. Each student is required to write a full report covering in detail a description of the apparatus, of the methods of making the test, of the results and conclusions, and is frequently required to compare his results with those given by various authors. The student is graded by the work he does in the experiment and by his report. In grading the report his attention is called to errors both in composition and numerical results by a single check mark which he must correct in a revised copy before his work on the experiment is finally accepted and marked.

In addition to the experiment and report, the students meet in class rooms once a week with one of their instructors and recite on the important points pertaining to the experiment in question.

For the three exercises, which are made up of (1) three hours of experimental work in the laboratory, (2) a recitation on the subject of the experiment, and (3) a written report, three hours of credit are given. Our experience has proved, however, that the amount of credit is too small in proportion to the work done since actual investigation shows that in order to do the laboratory work satisfactorily the student must put in from eleven to fourteen actual hours per week, the average being not far from twelve. In most studies it is deemed fair that a student should have one hour credit for three hours of actual work, whether it be a lecture or recitation, with two hours of preparation, or three hours spent in drafting or workshop. In accordance with that practice our students should receive about four hours credit for each laboratory exercise, but such an arrangement does not seem possible with the present crowded condition of the curriculum.

A considerable amount of research and investigation work is performed in the laboratory. This work is usually done either by graduate students or by those who have had the training of the undergraduate laboratory courses to which reference has been made in a general way. In the carrying out of some investigations the university has expended a considerable amount of money to provide suitable apparatus or materials to work with. The results of the investigation and research are generally fully recorded in the graduating theses.

Respecting theses, I would state that until the year

1906, they were compulsory for all members of the graduating class. During 1904–5, it was found impossible to provide the necessary facilities for the proper preparation of suitable thesis investigations for the large graduating class. On recommendation, the faculty therefore voted to permit the students to elect studies of a prescribed character having an equivalent amount of credit in place of theses. A result of this arrangement was that only about one third of the graduates of this year's class presented theses.

For the second degree a thesis involving quite an extended investigation is required.

The "Announcement of Courses of Study" which has recently been printed by the university shows the arrangements of studies in the different courses which have recently been adopted and which have now been carried into effect. It will be noted that no language studies appear in the course. This is not due to the fact that the study of languages has been curtailed, but is due to the fact that we now require the English, two years of French and two years of German, or their equivalent, as stated in the pamphlet referred to, before the student can be admitted. Our experience leads us to believe that students will be better trained in languages provided they take them before entering rather than during their college course, although this again will depend upon circumstances and conditions. The raising of the standard of admission, as noted, has given time for more technical work than has heretofore been given. As a good portion of this work is along the line of laboratory instruction, we believe that our men will in the future be much better trained for the practical problems of engineering life than they have been in the past.

THE FEDERAL POLYTECHNIC AT ZURICH FROM AN ADMINISTRATIVE STANDPOINT.*

BY H. W. TYLER,

Professor of Mathematics, Massachusetts Institute of Technology.

The following notes are based on the official publications of the polytechnic, supplemented by personal observation and conference with members of its faculty. The writer is much indebted to their courtesy, and particularly to the patience with which they received and answered numerous questions. No attempt was made to gain any acquaintance with equipment or the general methods and subject-matter of instruction, the object being to acquire a correct general understanding of organization and administrative methods, and of relations with the local university, and some notion of points of resemblance to or difference from American technological schools.

ORGANIZATION AND ADMINISTRATION.

The Federal Polytechnic is designed to serve the needs of all Switzerland for technological education. The federal council (*Bundesrat*) is accordingly the ultimate authority, electing the school council and its president and vice-president. Its jurisdiction includes also electing (or removing) professors and teachers and fixing their salaries, granting leaves of absence and retirement allowances, presenting the budget of the school to the federal legislature, determining the acceptance of gifts and bequests.

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These (and certain other) functions are exercised in general at the instance of the school council, with the intervention of the head of the department of the interior, who has a voice in all meetings of the school council.

The school council (*Schulrat*) is the active governing body, and its president is the executive head of the institution. It has the initiative in matters above mentioned as determined by the federal council; it elects the director and his substitute, and other administrative officers, except heads of departments, whom it has the right to confirm. (Its former right to elect these has been yielded to the professors.) It fixes salaries within the limits of budget set by the federal council, grants leaves of absence on occasion, appoints or removes teachers (*Privat Docenten*), apportions aid to students, determines laboratory and other fees, exercises oversight over the collections, reports annually to the federal council.

Besides these functions it has also the following powers and duties, although its exercise of them is, to a considerable extent, merely confirmatory: The approval of the semester programs; the determination of the school calendar and of the hours of exercises; action on the more serious cases of discipline, either on appeal or in original jurisdiction; the approval of the outlines of particular courses presented by the departments; the decision as to diplomas and prizes (the polytechnic has not yet the right to give degrees, but expects to receive it soon); the decision as to admission of students; any other needful functions not specially prescribed.

In the discharge of these functions it is obliged to secure the advice of the faculty (*Gesamtkonferenz*) or of the department (*Specialkonferenz*) on matters of importance. It—or its president—may enter into direct relations with any department or teacher.

The president (*Präsident*) must reside at Zürich. The other members are likely to live in different cantons. The president presents written recommendations, but any other member may also present business by motion. The president supervises the progress of the institution and its work, and is responsible for the carrying out of the decisions of the federal council and the school council. In the intervals of sessions of the latter, the president may deal with applications for admission, urgent cases of discipline, urgent cases of leave of absence and substitution, applications for remission of fees.

The director (*Direktor*) and his substitute are elected by the school council on the (double) nomination of the faculty for a term of two years, with eligibility for not more than six consecutive years. He attends sessions of the school council, except as otherwise ordered, and his principal functions are: To carry out decisions of the faculty; to exercise general oversight, acting as a co-ordinating and reporting agent between the school council, the faculty, and the departments; to present to the school council the programs based on data furnished by the departments; to co-operate with the president in deciding on questions of admission; to keep records and lists; to notify students and parents of action; to arrange diploma examinations; to deal with applications for change of department or leave of absence, with simple cases of discipline.

The heads of departments (*Vorstände*) are elected for two-year terms, with eligibility for not more than six consecutive years. Their duties include execution of departmental decisions, supervision of instruction and of students as to work and conduct, participation in questions of admission, decision as to substitution of studies or change of department.

The faculty (*Gesamtkonferenz*) consists of all professors and teachers, the professors alone constituting a special division for nominating the director and vice-director, etc. The director presides, and must call at least one session a year. It is the duty of the faculty to watch over the general development of the institution, and, in particular, to strive to keep all branches of its work in the closest and most vital relations with the chief aim of a practical and liberal education. The faculty appoints its secretary and committees; discusses propositions of the school council, the director, the departmental conferences, and of its own members; deals with cases of discipline of a general character.

The departmental conferences (*Abteilungskonferenzen*) include for each of the eight departments (see page 249) all officers of instruction, only the professors, however, having unrestricted right to vote.

The corresponding departmental conferences choose their own heads, as above stated, subject to confirmation by the school council. Their functions include the collection of quarterly reports of standing, the yearly promotion of students, simple cases of discipline, recommendations to the school council as to curriculum, subject-matter of courses, the award of diplomas and prizes, recommendations in regard to more serious cases of discipline.

The conference of heads of departments may be convened by the president or the director, or on request of any three members. It is charged with the duty of insuring the harmonious and well co-ordinated execution of the regulations and conclusions of the authorities (federal council and school council) in all departments. It may discuss, in a preliminary way, matters falling within the province of the other conferences (faculty or departmental) without, however, impairing their authority.

Remarks on Organization.

The test of any organization lies solely in its practical efficiency during a sufficiently long period, and such efficiency must depend on the adaptation of the organization to local conditions, the flexibility with which it meets new conditions, and the wisdom and good-will with which it is administered. On these fundamental matters a brief visit affords no basis for judgment. Subject to this important reservation, the writer's impressions of the organization in the abstract were somewhat as follows:

An element of fundamental and essential complexity is the mixed racial composition of the Swiss Republic. German elements preponderate, but French and Italian must always be reckoned with; and this necessarily implies more than the obvious linguistic difficulties. Again, any *federal* institution must be influenced by mere considerations of locality; for example, in the choice of members of the federal school council.

The functions of the federal council seem, from an American standpoint, to trench somewhat on the proper authority of a special board of trustees, as the school council, selected for educational administration. The president and trustees of an American state university would, for example, present to the legislature not a budget, but only a request for a general appropriation, and in particular cases for new buildings. The difference is, however, more apparent than real, the federal council actually leaving the authority substantially to the school council—a safeguard of which the value may well be different in different countries.

The keystone of the whole organization is evidently the school council, controlling the conduct of the school on the one hand and connecting it with the body politic on the other. Of the seven members of the school council for 1904–05, the president and vice-president and one other live in Zürich, one in Lucerne, one in Berne, one in Lausanne, one in Aarau. This dispersion of the members naturally militates against frequent meetings or intimate knowledge of the school on the part of its members.

It would therefore appear, as in the case of the federal council, that the successful discharge of many of the functions of the school council must depend on the extent to which it practically delegates them to its president or to other agencies responsible to it. In other words, the nominal powers of each council tend to be exercised by a subordinate body or bodies. Such conditions are not, of course, unfamiliar elsewhere. If it were a question of the delimitation of powers actually and fully exercised, it would seem that the school council might concern itself less with the details of educational and disciplinary routine than a literal interpretation of the regulations would imply.

The president's duties and powers appear to correspond somewhat closely with those of the corresponding officer in America. On the other hand, the most striking distinction from American usage seems to be the relative insignificance of the *Gesamtkonferenz,* the nearest analogue of our faculty. In Zürich the several departments appear to have much larger initiative and autonomy than would generally be the case in America. This corresponds with the fact that the students enter with more extensive attainments, and that their work at the polytechnic is, therefore, more specialized by departments from the beginning. It has the advantage of simplicity and directness, each department dealing merely with its own students. From an American standpoint these advantages might seem to be somewhat dearly purchased at the apparent cost of the closer co-ordination and healthful interaction gained by leaving similar initiative to the departments, but reserving the actual decision—for example, in such matters as recommendation for degrees, change of curriculum, etc.—to the faculty as a whole. In America, however, the common degree (S.B.) in all departments, the identical duration (four years) of all courses leading to it, and the generally greater emphasis on this uniformity have a bearing on the matter. In Zürich there is a logical acceptance of the principle of nonconformity among departments, some of them requiring only four or five semesters against the seven or eight of others. So far as the writer learned, there was general satisfaction with the existing degree of detachment of departments, and no disposition to desire increased co-ordination or centralization.

Another conspicuous contrast with American conditions is found in the election for limited periods of the director and the heads of departments. In comparison with the system of appointment for indefinite terms this seems more democratic, and the resulting identification of administrative with teaching functions, as well as the distribution of the former among a larger number of professors, have obvious advantages. How far these may be offset by the loss of continuity the writer could not judge. The provision permitting re-election up to a total period of six years was said to be generally exercised. The plan would appear to be in line with the non-centralization referred to in connection with the separateness of departments, and may have some tendency to increase the relative authority of those administrative officers having unlimited tenure—the president and secretary of the school council, on the one hand, the staff of the director on the other.

Relations with the University.

The polytechnic was founded by the Swiss Republic in 1855, and in connection with its location in Zürich the canton undertook to house it with the cantonal university already existing. Accordingly, the fine and extensive main building is still shared by the two institutions, certain collections are used by both, and certain professors give instruction in both. This connection—evidently neither close, nor organic, nor fundamental—tends to diminish as time passes, and would probably have been terminated long since but for the complications due to the original ownership of the entire main building by the canton. A separation such as is now contemplated must apparently mean the purchase of the remaining cantonal part of this building by the confederation. It may be added that both institutions now have other buildings in which there is nowhere such association.

The polytechnic not having at present the right to confer degrees, an arrangement exists by which the university confers its Ph.D. on candidates recommended by the polytechnic. A thesis must, however, be presented in each case for approval by the faculty of the university.

REQUIREMENTS FOR ADMISSION.

As a state school, the polytechnic adjusts its admission requirements to the possible performance of the secondary schools preparing its students. The delegates of the federal school council—usually with one professor—attend the final examinations of the school, and acceptance of its certificates for admission is a matter of special agreement. The relations with these schools were said to be effective and mutually advantageous. The age requirement is eighteen, and the actual average is about nineteen.

On the presentation of a candidate's credentials the president decides, on recommendation of the director, whether he shall be admitted subject to or without examination. Candidates who have failed at their certificate examinations in accredited schools are not admitted immediately to the polytechnic examinations. Exceptionally mature age receives consideration as a claim to admission.

The examination is divided into a first part—general subjects—and a second—mathematics, physics, and chemistry.

The examining board (*Prüfungskommission*) consist of the president and at least one member of the school council, the director, all the heads of departments, examiners selected from the instructing staff for two years each by the school council.

The heads of departments have a vote only as to the admission of candidates for their respective departments.

REQUIREMENTS IN GENERAL EDUCATION.

1. The candidate is required to write a composition showing his ability to handle correctly some subject with which he is acquainted as to orthography, style, and logic, in German, French, Italian, or English.

2. He must show by oral examinations his practical command of the languages—German, and in certain cases French—in which obligatory instruction will be given.

3. He is examined orally in History of Literature—German, French, Italian, English, or Ancient; Political History (General, and for native candidates Swiss History and Constitution); Natural Sciences—fundamental facts of the animal, vegetable, and mineral kingdoms, including the structure and functions of the human body.

REQUIREMENTS IN PROFESSIONAL SUBJECTS.

1. *Arithmetic and Algebra,* including, for example, logarithms, continued fractions, binomial theorem, simple exponential equations, exponential, logarithmic, and the simpler trigonometric series.

2. *Geometry,* plane and solid, including transversals, construction problems, determination of volumes and surfaces; plane trigonometry and the elements of spherical; analytic geometry, including the simplest equations of the conics and the elements of solid analytic geometry.

3. *Descriptive Geometry.*

4. *Physics.*

5. *Chemistry.*

6. *Drawing,* freehand and mechanical.

The great majority of the Swiss students come from the non-classical secondary schools.

CURRICULUM.

The general scope of the curriculum is determined by the federal council, to which, for example, the introduction of a new department must be submitted by the school council for approval. The law of July, 1899, designates the following departments:

I. Architecture (*Hochbau, Architekten Schule*).

II. Civil engineering (*Strassen-, Eisenbahn-, Wasser-, und Brückenbau, sowie Vermessungswesen; Ingenieur-Schule*).

III. Mechanical engineering (*Industrielle Mechanik; mechanisch-technische Schule*).

IV. Technical chemistry (*Industrielle Chemie; chemisch-technische Schule*): (*a*) Technical section, (*b*) pharmaceutical section.

V. Agriculture and forestry (*Land- und Forstwirtschaft*): Forestry, agriculture, rural engineering (*Kultur Ingenieur-Schule*).

VI. Department for teachers of science (*Bildung von Fachlehrern in mathematischer und naturwissenschaftlicher Richtung*): (*a*) Mathematical-physical section, (*b*) natural science section.

VII. General department (*Allgemeine philosophische und staatswirtschaftliche Abteilung: Freifächer*).

VIII. Military department (*Militärwissenschaftliche Abteilung*).

Subjects not required in any of the first six—the professional departments—are grouped in the seventh.

It is required that in all departments instruction shall be given with constant regard to the special needs of Switzerland.

The prescribed vacation periods amount to thirteen weeks, eight in August and September, two at Christmas, three in the spring.

The number of semesters required in different courses is as follows: Architecture, civil and mechanical engineering, require seven semesters and an eighth for a thesis; technical chemistry, seven; pharmaceutical chemistry, four; forestry, six; agriculture, five and a sixth for a thesis; rural engineering, five; mathematical and physical science, eight; natural science, six or eight.

An inspection of the programs shows that the polytechnic concerns itself with the professional, and not with the general education of its students. This statement may be qualified, however, by the remark that a great variety of general subjects are offered as electives, and that students are required to take one or more of these in later years. Moreover, the previous general education represented by the entrance requirements is considerably more extensive than is the case in the United States. Nevertheless, it would seem at least possible that students entering the polytechnic at about nineteen might advantageously be subjected to some further prescription in general studies. Such subjects as mathematics, descriptive geometry, mechanics, are naturally given to students of different departments together. On the other hand, the importance of division and differentiation of the instruction in physics was emphasized. Students in architecture and chemistry have an abridged course in mathematics.

In the first semester of the two engineering courses differential calculus is a common subject, with 4 hours per week of lecture, 3 of section work (*Repetitorium,* 1; *Uebung,* 2). At the same time analytic geometry has 4 hours per week of lecture and 1 of section work, descriptive geometry 4 hours of lecture and 5 of exercise. In the second semester, integral calculus occupies 7 hours per week, mechanics 9; in the third, differential equations 5, mechanics 7, physics 5; in the fourth, physics 5. Business law appears in the later semesters of all programmes, political economy in several.

The course in rural engineering (5 semesters), a subdivision of that in agriculture and forestry, differs very little in the first semester from the course in civil engineering. In the second semester it omits descriptive geometry and mechanics, and includes physics, surveying, roads and canals. In the third it omits differential equations, mechanics, graphical statics, and theory of machines, and includes surveying, roads and canals, meteorology, etc., the two thus ceasing to have any considerable resemblance.

The two courses for teachers of science, one in mathematical and physical science, the other in natural science, are not definitely laid out, but each student may work out his own programme in consultation with the head of his course. Seminar work in mathematics and physics is offered in the latter half of the four-year course. In the first year the program of the mathematical-physical course corresponds rather closely with the engineering courses. The course in natural sciences includes a large proportion of chemistry, but more mathematics than the course in technical chemistry, as well as other branches of natural and physical science.

In all the programs examined the total number of hours per week seemed large, this being explained in part by the length of the day—7 to 12 and 2 to 7 in the summer, 8 to 12 and 2 to 7 in the winter. The extreme hours are naturally used relatively little, but teachers and students must obviously live near at hand. There is marked concentration of time in principal subjects, and this is further notable in the timetable, where time is used in large blocks, even lectures often occupying two consecutive hours; *i. e.,* ninety minutes.

The number of subjects per semester in the four principal courses, as shown in the following table, ranged from five to nine in the first three semesters, from six to fourteen in the last four. The average is six in the former period, ten in the latter. The assignment of time for exercises varies from twenty-nine hours in the first semester of mechanical engineering to not less than sixty in the fifth semester of technical chemistry.

	Number of Subjects by Semesters.							Number of Hours per Week by Semesters.						
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Architecture	8	7	9	10	8	10	7	41	38	46	51	39	48	34
Civil Engineering	6	6	6	6	9	9	14	33	38	34	40	43	42	40
Mechanical Engineering	5	5	6	8	9	11	14	29	31	36	39	41	44	46
Technical Chemistry ..	5	5	8	6	13	12	7	42	39	42	32	60	54	39

Courses of but one or two hours per week are common only among the non-technical subjects.

The use of lectures and the dependence on the students' own notes seemed to the writer to be carried—as elsewhere in Europe—beyond the point of best economy; but observations on this point were limited. Text-books and printed notes have their inevitable defects, but the working out of satisfactory notes by the student consumes much time, and its value may be easily overrated.

Research seems to be highly esteemed and effectively practiced in the various departments.

TEACHERS.

The grades of the instructing staff are: Professor, associate (*Hülfslehrer*), *Privat Docent* (usually confined to elective subjects), assistant.

Teachers are required to give announced courses for three or more hearers, or even for one in the case of required subjects. Each must present the titles of his required courses to the director's office, from which the collected material is referred to the heads of departments for the approval of the departmental conferences. A teacher must report to the director any detention from an exercise, and, if detained more than three days, must apply to the school council for leave of absence. A teacher appointed for life—which appears not to be frequently the case—who becomes disabled by age or illness may be retired by the federal council at the instance of the school council, receiving a proportion (not fixed) of his salary. Removal requires similar procedure.

Directors and heads of departments are required to render an exact account of the finances and condition of their collections and equipment annually.

For the first semester of 1904–05 the total number of subjects announced is 405, counting recitations (*Repetitorien*) separately, including 58 by 31 *Privat Docenten.* The number of professors is 78, of assistants 62 (including 4 places not filled).

The writer found keen interest on the part of the professors in the sabbatical year plan which he was supposed to exemplify, but was obliged to confess that only the strongest American institutions had yet been able to establish it.

STUDENTS.

Students may be regular students or auditors (*Zuhörer*), something between our special students and "listeners." The former are required to follow one of the more or less definitely prescribed programs, except as permission for substitution of subjects may be approved for special reasons by the heads of their departments. A considerable amount of election is allowed after the first two years. Every regular student must take at least one of the elective subjects in each semester. The tuition fee is 150 francs, besides small fees for the library, the hospital, and accident insurance. Laboratory fees are also additional.

Auditors may attend the elective courses subject to the age requirement and to presenting a certificate of character. Admission to professional subjects, however, requires examination or equivalent certificates, except in the case of men of mature age engaged in technical pursuits. Poor and able students may receive pecuniary aid, in addition to the remission of tuition. In disciplinary matters students are subject to general police regulations, and may be specially dealt with by the officers of the polytechnic for neglect of studies, disrespect and disobedience towards the school authorities and teachers, disturbances and duels.

Penalties include reprimands by the head of the department, the director, the president, or the school council, probation, cancellation of registration, dismissal. The last is determined by the school council, and is posted. It is the usual punishment for participation in a duel. The by-laws of student societies and list of members are subject to inspection.

A student's promotion at the end of the year is determined by the departmental conferences on the basis of his work for the year. Two successive failures result in dismissal.

The diploma is an earned distinction. The school council directs the oral examination, which is public, and is divided into two parts, of which the first is taken at the beginning of the fifth semester (in the departments which have been above discussed). The examining committee consists of the head of the department and the examiners. A rank is given in each examination subject, and a definite weight is applied in each. Excellent previous work receives consideration. Success with the preliminary examination is required for admission to the final, and the results of both are considered in the award of diplomas. The examining committee reports for both to the school council, including details and possible expressions of dissent. In particular cases, diplomas are "with distinction." Either examination may be repeated after a year's interval.

A thesis (*Diplomarbeit*) is an essential accompaniment of the final examination. In the department of architecture, there are 5 preliminary examination subjects, 7 final, and the thesis is equivalent in weight to 7 examinations. In civil engineering, there are 6 preliminary subjects, of which 4 have double weight, 7 final. The thesis has weight, 3 or 4. In mechanical engineering, there are 6 preliminary subjects, of which 3 have double weight, 6 final, including 4 double, the thesis counting as 3, etc. About 80 per cent. of the regular students apply for the preliminary examinations, about three-fourths of these passing, and about one-half receiving diplomas.

A professor having some acquaintance with American institutions expressed the opinion that these directed their work and attention relatively more to the weaker students, and, in general, occupied themselves more with the personal welfare of students.

STATISTICS FOR 1903–04.

REGULAR STUDENTS.

	Swiss.	Foreign.	Total.
Architecture	53	8	61
Civil Engineering	213	70	283
Mechanical Engineering	271	251	522
Chemistry:			
(a) Technical	136	101	237
(b) Pharmaceutical	3	1	4
Forestry	30		30
Agriculture	43	8	51
Rural Engineering	17	5	22
Teachers:			
Mathematical-Physical	19	5	24
Natural Science	22	7	29
	807	456	1,263
Hearers registered			657
			1,920

Of the foreign students, 113 came from Austro-Hungary, 59 from Russia, 56 from Italy, 40 from Germany, 33 from Holland, 28 from France, 26 from Roumania, 22 from Great Britain, 14 from America (North and South), etc. It is an eloquent testimony to the wise liberality of the Swiss Republic—neither great nor wealthy in comparison with many of these countries—that it furnishes so admirable an education to all comers at a nominal cost, with no thought of discrimination or direct return.

REPORT OF THE COMMITTEE ON ENTRANCE REQUIREMENTS.

BY J. J. FLATHER, *Chairman.*

The aim of the committee for the past few years has been to obtain an expression of definition of subject so that recommendations might be made, looking to a greater uniformity in regard to accepted definition. With a few exceptions, this uniformity of definition for college entrance subjects has been accepted by various educational and scientific interests and substantial agreement has been reached with reference to mathematics, history and the languages, including English. It has been, however, impossible to agree upon definitions of requirement in the sciences, manual training and drawing.

While it is generally admitted that the requirements for physics and chemistry formulated by the Committee of Ten appointed by the National Educational Association a number of years ago are too extensive and should be reduced very materially, yet there seems to be a practical difficulty in determining what should be omitted.

An effort was made two years ago to have the National Societies interested in physics and chemistry formulate such a set of requirements and definitions, but at the time the societies did not care to undertake such a problem and the matter was dropped. However, it is the opinion of this committee that neither in physics nor chemistry as generally taught by the high schools of the country is the formulation lived up to; in fact there are very few such schools in a position to teach the subjects as outlined by the committee of the N. E. A. Therefore it seems wise to reduce these requirements, and to this end expressions of opinion have been obtained from a number of teachers in these sciences, both in technical colleges and high schools; it is hoped that in the near future a resume of these will be presented to the members of the society for an expression of their opinion, from which a final report will be prepared.

Some few years ago a sub-committee from the Committee on Entrance Requirements was appointed to meet with a similar committee to be appointed by the N. E. A., but the latter association did not appoint the committee in sufficient time to have a conference as was anticipated, and no opportunity of a joint meeting has since been offered. It was hoped that a conference would be held during the past year at San Francisco, but the recent disaster has prevented the annual meeting of the N. E. A. this year, so the matter stands just as it was.

The same is true regarding manual training and drawing. Suggested formulations were sent to a number of men particularly interested in these subjects with a request for criticisms, but the opinions received were so varied and even antagonistic that no general formulations could be made. One of the national societies for manual training teachers formulated a set of definitions for shop work, which definitions were based entirely upon the time spent on the subject, but it seems that some general statement of what is to be taught in addition to the time limit should be given, and it is probable that the final report of the committee will include some such relation; that is, while the time spent on manual training should be taken into account, yet the character of the work should also be considered, and when we speak of carpentry, or machine-shop work, we should have some definite idea as to what is meant by the subjects rather than simply a reference to the time spent. In some manual training schools, forging is taught by hammering out lead and foundry practice is taught by casting lead, but while this has a certain value in itself, it would hardly meet with the general approval of engineers. Therefore it seems better to state exactly what should be required in these subjects if they are to be accepted for entrance.

The question of definition for manual training subjects is complicated by the fact that many schools teach manual training so thoroughly that these subjects are accepted not only for entrance, but advanced credit is very frequently given. The question of advanced credit, however, is one which must be settled by each technical college individually, and the present aim is to obtain a substantial agreement as to what is meant by the various subdivisions of manual training as far as entrance credits are concerned.

J. P. JACKSON,
MANSFIELD MERRIMAN,
C. D. MARX,
F. W. MCNAIR,
F. O. MARVIN,
J. C. NAGLE,
R. B. OWENS,
W. D. PENCE,
J. J. FLATHER, *Chairman,*
Committee.

TOPICAL DISCUSSION: WHAT MODIFICATIONS IN ENGINEERING INSTRUCTION ARE DEMANDED BY RECENT ADVANCE IN PRACTICE?

Professor Landreth: The title calls for discussion on desired modifications in engineering instruction demanded by recent advance in practice. If the question were modified to the form "what modifications in engineering instruction are demanded by present professional requirements?" it would admit of a more definite and useful discussion.

"Recent practice" and "professional requirements" are not necessarily identical. Practice, like instruction is apt to lag behind professional requirements to a greater or less extent according to various factors, one of which is the character of engineering instruction itself.

It must be evident to everyone who keeps in touch on one hand with present professional demands and possibilities, and on the other with current instruction as inferred from the preparation shown by young engineers and from the typical engineering curriculum, that professional demands and possibilities strongly call for development of engineering training in two directions, viz., the development of the administrative faculty and the cultivation of the æsthetic sense and taste.

The increasing frequency with which engineers are now thrown into relations and situations calling for the exercise of executive and administrative functions, and the favorable possibilities open to engineers who possess such capacity in well-developed degree, make the question a pertinent one, whether the training at college or in the engineering school can be made more effective in aiding the development of this special ability. No school can, of course, make business men or successful administrators of its students; neither for that matter can it make engineers of them; but there appears no ground for doubt that it may do for their business training what it certainly now does for their strictly technical training, viz., introduce the subject to them in a systematic and rational manner and then thoroughly inculcate the fundamental principles of the subject, thus giving the young engineer a framework on which to build and classify the results of his experience.

In a paper entitled "The Study of the Principles of Administration in Engineering Schools,"* read by the speaker before this society at the Buffalo meeting in 1901, the subject was presented at some length under the following heads:

1. Are there clear-cut, definitely-expressible principles of administration which may be formulated in such general terms as to be comprehensive, and still sufficiently definite to be useful as guides in practice?
2. Does the work of the engineer, in its numerous divisions and ever-widening scope, call for administrative ability?
3. To what extent, and how, may the work of the engineering school be made to contribute most effectively to the development of this administrative ability?

It is not intended to enter again into a detailed consideration of the importance or scope of the training proposed, nor of the details of possible plans for giving the instruction. These latter must of necessity be developed by each school in accordance with its own policies and its own controlling conditions and circumstances. The recognition of the necessity for such administrative training as an essential part of the outfitting of the young engineer, once having been generally established, the elaboration of ways and means as well as of details will naturally follow.

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* The paper was withdrawn by the writer for some corrections after being read, and was prevented by an emergency from being returned in time for publication.—O. H. L.

Turning to the other topic of suggested importance in the young engineer's training, viz., the development of his æsthetic character, the subject lays claim to a two-fold consideration—the broadening of the man and the increase in his capacity for enjoyment and for filling the sphere of a cultured citizen on one hand, and on the other the utilitarian, though not less valuable accession to his economic capacity as a designer of things that shall be at the same time beautiful and inspiring, as well as strong, durable and efficient.

Under the stimulation of a new country, the absence of trammeling precedents and conditions, and strong free competition, American engineers have taken first rank in efficiency of design and construction when tested by strictly commercial or utilitarian standards. Unfortunately less than this must be said of their work when examined for grace and beauty or for the presence of that artistic fitness which is the essential harmony between the form and the substance, between beauty and usefulness, between the artistic and the utilitarian, in the engineer's work. The reasons for this discrepancy between the constructive and the artistic efficiency of our engineers are the natural and logical results of our past national environment, necessities and development. We have neglected the beautiful in our engineering constructions because we could and were obliged to do without it, because our people as a whole did not miss it nor demand it, and finally because our engineers were not trained to supply it. But all this is changed, or changing. Our wealth and education now make culture and art possible and warrant full consideration for the beautiful. Our people in larger measure than formerly appreciate and demand it, and our engineers must respond and supply it.

This subject has been most admirably treated by Prof. Frank O. Marvin in a carefully prepared paper entitled "The Artistic Element in Engineering," which was presented as the vice-presidential address before Section D, "Mechanical Science and Engineering," of the American Association for the Advancement of Science at the Buffalo meeting in 1896 and appears in the proceedings of that meeting. It is not over-drawn approbation of this paper to say of it that nothing has appeared which so intelligibly and so hopefully treats the subject by pointing out the shortcomings, outlining the possibilities, and urging the further development of the artistic element in engineering training and work.

FRAUD IN EXAMINATIONS.

BY FRANCIS C. CALDWELL,

Professor of Electrical Engineering, Ohio State University.

The subject chosen for this paper is one of the least pleasant with which the educator of the present day has to deal, but it is one which is now demanding his attention most urgently. The force of this demand doubtless varies greatly in different institutions. But one of the most serious features connected with this question of fraud is the difficulty of knowing when and to what extent it exists. Again and again instructors have stated that there was no fraud in their classes; they knew that they were able to watch the students so thoroughly that nothing of that sort could be done; and yet former students of these same instructors have told of case after case where fraud had occurred. One therefore accepts with much hesitation the statement of anyone that fraud is absent from his classes, without first investigating the grounds for his assurance.

Different cases of this evil can be pretty accurately distributed into two classes; in the one the students bring with them written or printed matter, commonly known as "ponies," while in the other, the illicit information is obtained from others who are taking the examination. Of these two, the latter is probably the more common form of fraud. To prepare a pony and take it into a classroom implies a degree of premeditated wrong-doing of which, it is thought, not many college students are guilty; it is a form commonly employed by the more capable students, who have neglected their work during the term, and its successful use usually implies rather a high degree of expertness. On the other hand the obtaining of information from the other members of the class is often not premeditated and is done because the recipient finds himself in imminent danger of failure and therefore under extraordinary temptation.

From these facts it follows that the first form of fraud is the more likely to aid in sending out from the university dishonest men. While there are many who are inclined to make a distinction between dishonesty in school work and dishonesty in other matters, it is hard to believe that the man who will deliberately cheat in his class work will be scrupulous in his methods when he sees an opportunity to advance his interests in after life. On the other hand, the second form of dishonesty is chiefly responsible for lowering the standing of the college graduate as a man of ability. It unquestionably allows an appreciable number of men to gain college degrees who would otherwise not be able to complete the course.

The question as to which of these forms of fraud is the more deplorable is an open one. The obtaining of information from others during examination is unquestionably the more insidious and the more calculated to break down the honesty of weak men. There can be little doubt that many a student has committed his first fraud through accidentally catching a glimpse of the work of another student sitting near him. Thus, as an efficient means of training students in dishonesty, especially where due precautions are not taken to make such inter-communication between them difficult, this form of fraud should be regarded as a most serious menace. On the other hand, the use of the pony tends to keep in college, as members of the student body, dishonest men who would otherwise be eliminated and who cannot but produce an evil effect upon their fellow students.

In the conduct of examinations we find two radically different systems in use as well as an almost continuous gradation of practices lying between these methods as extremes. In the one method the student is definitely placed upon his honor and then left to work out the examination without any special surveillance, the attendant in the examination room making no special effort to watch the students, sometimes going even so far as to absent himself during shorter or longer intervals. This method is commonly known as the honor system of examination. In the other method known as the proctor system, or the police system, the assumption is made that there are liable to be dishonest men in every class and that the whole class must be carefully watched to prevent these unknown dishonest men from committing fraud. This system is carried out with greatly varied degrees of effectiveness. Perhaps an extreme is found at Harvard, where the instructor has no function in the examination except the preparation of the questions and the grading of the papers. The conduct of the examination is entirely in the hands of an examining board who employ the fellows and graduate students to act as proctors or policing force. These proctors are supposed to devote their attention entirely to the surveillance of the students during examination and the intention is to assign enough to each room so that the work can be most thoroughly done.

In some other institutions, although the examinations are in charge of the instructors or at least of the departments, definite faculty rules are in force, specifying the number of proctors which must be present in every room. In still others, and probably in the largest number of cases, the conduct of the examination is left entirely to the instructor giving the course, and he watches the students, be the class large or small, with a varying degree of effectiveness. In this case also he is likely to begin to place some faith in the honesty of his class, to take a book with him into the class room and read a little or to stand with his back to the class looking out of the window, or even to leave for a moment and go into an adjoining room. So much is this the case that it is hard to tell just where the application of the honor system proper begins. There are unquestionably fine teachers who, without saying a word to their class upon the subject, so command their respect and so make them feel the dishonor of fraud, that it is safe in an unusual degree for them to trust to the honesty of their students. In general, however, there can be no question but that this intermediate class, where the students are not definitely made to feel that they are trusted and where they are not carefully watched, is the most productive of fraud and the most calculated to develop it in an institution. In some institutions, which are certainly to be most heartily congratulated, such a high spirit of honor amongst the students has been developed that this matter is entirely handled by them. The faculty is not obliged to give attention to the question of honesty and the occasional cases of fraud are so handled by the students that there is likely to be no repetition.

In some institutions there are no general rules with regard to the conduct of examinations and each instructor applies the proctor system, or the honor system, or any intermediate combination of the two which happens to take his fancy. The result of an inquiry among the better class of students in one such institution seems to indicate that there is little to choose, so far as the actual prevention of fraud is concerned, between the carefully policed class and one in which the students are definitely placed upon their honor. There is always likely to be some fraud; for there are usually some who are expert enough to outwit the most careful system of watching, and some who are so degraded that the question of honor does not ap peal to them at all.

It is, however, an interesting question as to whether a systematic application of the honor system throughout an institution would or would not be more calculated to develop a higher grade of public morals than would a thoroughgoing police system. If the students could be brought to regard the proctors in the right light, in the same way that the good citizens of a community regard the officers of the law, this system would have much to recommend it. It is, however, questionable whether this can usually be accomplished. There is the essential difference that the proctors are not appointed by the students who are being watched, and there is a very strong tendency to regard the examination as a kind of game between the student and the proctor. If the student can cheat without being caught by the proctor, he wins. If the proctor succeeds in catching the student, he wins. If he simply succeeds in preventing the student from cheating, it is a drawn game. This is of course an entirely wrong way to look at the matter, but there is certainly a strong tendency among younger students to regard it in this way. There can, however, be no question but that either a well conducted police system, or a thoroughgoing honor system, is much to be preferred to a cross between them.

While in the honor system of examinations, theoretically, implicit trust is placed in the honesty of the students, the question of just how far this theory should be carried out in practice is an important one. It would seem to be a safe statement of the case that while the students should not be obtrusively watched during an examination, all reasonable precautions should be taken to remove temptation from their way. There are always well intentioned but morally weak students to be considered, and with the prospect of failure and disgrace staring them in the face, the temptation may become very strong. Keeping students so separated that they cannot see their neighbors' papers without making a special effort to do so, is one of the most important of these precautions. Where it is absolutely necessary to place the students in closely adjacent seats this difficulty can be overcome by using two sets of examination questions, one for the odd and one for the even seats. This procedure makes a little more trouble for the instructor, but entirely does away with the objection to having the students in adjacent seats. The propriety of the instructors leaving the room may be more open to discussion, but even this results in a considerable and an entirely unnecessary temptation. Talking at such times is a much more conspicuous form of fraud, and consequently one less apt to be perpetrated than the overlooking of another's paper, when the latter can be done without even raising the eyes. The importance of using a suitable examination tablet and thereby avoiding the dangers of loose papers is generally conceded.

Obviously what has been said with regard to the conduct of examinations given under the honor system holds with even greater force for those given under the proctor system. The above mentioned practice of giving the same examination questions to students located in closely adjacent seats is deserving of another and especial word of condemnation. There can be no question but that students are often in doubt as to whether they would have been able to solve a problem by themselves had they not unintentionally caught a glimpse of their neighbor's work from which they received the clue they were seeking.

The question of the punishment which should be inflicted upon students guilty of fraud in examinations is another very important aspect of the case. A not unusual penalty and one which in the abstract is certainly deserved, is suspension from college. This, however, appears to many to be rather severe in the case of a first offense, and especially where it appears that there was no premeditated arrangement. One bad result of this is that in such cases instructors are liable to take the matter in their own hands and to refrain from reporting the case to higher authorities. This results in some students receiving a heavier penalty than others for the same offense, and is distinctly subversive to the highest degree of discipline.

In conclusion, it would seem that if there were one thing which an engineering education should develop more than another it would be a strict and uncompromising sense of honor and if those who are responsible for that education could by taking thought so amend their methods as to advance this side of their education, no expenditure of time and effort in bringing it about should be considered too great.

THE CORRESPONDENCE SCHOOL—ITS RELATION TO TECHNICAL EDUCATION AND SOME OF ITS RESULTS.

BY JOHN J. CLARK,

Dean of the Faculty of the International Correspondence Schools.

At the 1899 meeting of the Society for Promotion of Engineering Education, held at Columbus, Ohio, a paper was presented by Professor Edgar Marburg, entitled "The Correspondence School in Technical Education."* This paper aroused considerable interest, and was discussed quite generally, with the result that a committee on industrial education was appointed, of which Professor J. B. Johnson was chairman. This committee reported at the New York meeting in the following year.†

At the time Professor Marburg prepared his paper the total number of students enrolled in the International Correspondence Schools was about 80,000, and at the time the committee made its report the number of students enrolled was about 181,000. It was impossible at that time to furnish reliable figures in regard to the work being accomplished; consequently, both Professor Marburg's paper and the report of the committee were, in some respects, unsatisfactory and unjust to the correspondence school.

In order that you may understand several of the facts that I am about to bring to your attention, it will be well to consider the enrolment figures for the various years since the organization of the International Correspondence Schools.

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* *Proceedings of the Society for the Promotion of Engineering Education,* Vol. VII., p. 80.

† *Proceedings of the Society for the Promotion of Engineering Education,* Vol. VIII., p. 28.

From October 1, 1891, to December 31, 1893, the total number of students enrolled was	3,105
The number of new students enrolled to December 31, 1894	2,509
The number of new students enrolled to December 31, 1895	4,491
The number of new students enrolled to December 31, 1896	6,530
The number of new students enrolled to December 31, 1897	13,677
The number of new students enrolled to December 31, 1898	38,572
The number of new students enrolled to December 31, 1899	71,885

Since December 31, 1899, we have been enrolling students at the rate of more than 100,000 per year, the total number to and including June 27, 1906, being 902,906.

It will be noted that up to and including the enrolment for 1897, the increase in the number of students was comparatively even. After this date, however, the number of students enrolled increased very remarkably. There are two reasons for this sudden increase in the enrolment. Previous to January 1, 1898, the students received their text-books in the form of paper-covered pamphlets, averaging about fifty pages each, and these were sent only one at a time to each student as he progressed with his studies. The result was that if a student failed to complete his course, he had on hand not more than two instruction papers in advance of the last one he had studied. This tended to create great dissatisfaction, and, to overcome it, we reprinted the entire text of the courses, and sent to every student, at the time of his enrolment, a set of what we term bound volumes. These volumes contained every thing that the student would receive in connection with his course of instruction, and if he failed to complete the course he had his bound volumes at any rate, and could continue studying by himself, if he so desired. This feature resulted in a great increase in the number of students. Further, previous to the latter part of 1897, the students were obtained solely by newspaper and magazine advertising. They were all enrolled through the mails and no pressure was applied to induce them to become students. About the time we began printing bound volumes we began to organize a force of solicitors. These solicitors interviewed the prospective student personally, and naturally did everything they could to increase the number of students. The result is shown by the figures above quoted.

In 1899 and 1900, the number of new students enrolled was so great, relatively speaking, that it was impossible to furnish any definite figures to the committee or to Professor Marburg to substantiate our claims, and we ourselves could not predict definitely what the outcome would be. The enrolment has been comparatively steady during the past seven years, and we are now better able to present to the society facts and statistics that will enable you to judge of the work we are doing. At the same time, we can not give you full and complete information in regard to the benefits derived by our students. We have received hundreds and thousands of letters from students who have never sent in any work at all to be examined and corrected, or who have sent in work on only one subject—as for example, arithmetic—in which letters they have stated that they have derived great benefit from their courses. On inquiry we found that these students had studied from their bound volumes, and that the text had been so carefully prepared that they did not desire to go to the trouble of writing out the answers to the examination questions; and not caring whether or not they obtained a diploma or certificate, they never sent in any work.

Before pursuing this subject further, it will be well to consider the character of the courses we offer, and the reason why we offer so many different courses. Our system of education is based on an idea that is almost directly opposite the views held by the regular schools and colleges. The regular technical school or college aims to educate a man broadly; our aim, on the contrary, is to educate him only along some particular line. The college demands that a student shall have certain educational qualifications to enter it, and that all students study for approximately the same length of time, and when they have finished their courses they are supposed to be qualified to enter any one of a number of branches in some particular profession. We, on the contrary, are aiming to make our courses fit the particular needs of the student who takes them. If a student is employed as a helper in some shop, and desires to become a stationary engineer or draftsman, or bookkeeper, or to follow any other special branch of industry, we can offer him a course that will fit him for the particular position he has in mind. Such a student does not wish or desire to be forced to study anything that is not strictly necessary for him to learn in order to fill the position he is aiming at. Consequently, without citing other instances, it may be stated that every one of our courses, with a few exceptions, perhaps, is a special course. If a person desires to take up bridge engineering, and does not wish to learn the other branches of civil engineering, we offer him our bridge engineering course. He studies only those subjects that are necessary for him to know in order for him to understand everything we teach in regard to bridge engineering. If the person wishes to study stenography, we offer him our stenographic course. If, however, he wishes to take a course that would correspond to a course in a business college, we offer him what we term our complete commercial course, which includes bookkeeping, stenography and other subjects. If a student desires to study mechanical drawing, and does not wish to take our mechanical or mechanical engineering course, we will offer him our course in mechanical drawing, and will not compel him to study any other subject. There are many persons who already have a good knowledge of mathematics and who have a good general education. They find it necessary to have some knowledge of mechanical drawing, but do not wish to study any other subject. Such a person can take our mechanical-drawing course and learn the latest and best methods in use in the leading drafting rooms of the country.

Considered from a pedagogical standpoint, our methods are a distinct departure from any that have previously been tried. What has been stated here with regard to the methods of the International Correspondence Schools, applies with equal force to a number of other correspondence schools. These remarks do not apply to all correspondence schools, however, for the reason that some of them are conducted along an entirely different line. Attempts have been made to conduct correspondence schools by means of what may be termed the regular text-books such as are used in the ordinary school or college. Their plan is to purchase these text-books, direct the student to study a certain number of pages or chapters and then answer a set of questions. The student's answers are corrected and returned to him, and if he desires to be informed regarding anything not clearly explained in the text, he may write to the schools and obtain the information desired. He proceeds in this way until he has finished the particular text-book he is studying. Such schools, however, have always failed, or at any rate have made very little progress, for the reason that the ordinary text-book is not adapted to the use of a person studying by himself. Another method is that in use by the University of Chicago. The student takes a regular college course, but does a part of the work at home. He can not get his degree, however, without taking about half the course in residence. This plan offers very few advantages over taking a college course in the regular manner. The student must have the same preparation and must do the same amount of work as any other student taking the same course or subject. The only requirement necessary to become a student of the International Correspondence Schools is ability to read the English language and to write it sufficiently well to be understood. Sometimes even this requirement is not fulfilled, as the student will get some one else to write his answers to the examination questions for him, from dictation. This is especially true of students speaking some language other than English. A case came up only a short time ago of a German who was unable to write English, but who induced his wife to translate the text matter to him. He dictated the answers to the examination questions, which she wrote down, and his work was corrected by our instruction department in the usual way. This is not an isolated case, but is one that occurs with considerable frequency among such students.

Inasmuch as nearly every student has a definite object in view when he takes a course, he naturally objects to anything that will delay him in obtaining the knowledge he desires. As a consequence, we frequently have several text-books treating the same subject. In some cases the text-books differ quite materially both in the amount of ground covered and in the treatment; in other cases they differ very slightly. For example, take the subject of arithmetic. We have a very complete arithmetic that is used in our English branches, teachers' and commercial courses, while for our technical courses the arithmetics are all of about the same size; they may differ slightly in the methods of treatment, but principally in the fact that the examples and illustrative citations, etc., relate to matters with which the student is supposed to be concerned in connection with his course of study. For example: in the arithmetic used in the school of mines, the examples relate to matters pertaining to mining. Another arithmetic—very similar, but having different examples and illustrative citations—is used for the courses in the school of metallurgy. This may appear to be stretching the point considerably, but our chief aim is to keep the student interested in his work and to teach him something bearing directly on the course he is taking in connection with the study of every subject in that course.

As to the results we have accomplished, it is, as before stated, impossible to furnish exact figures. Many students enrol for the purpose of studying certain subjects that will enable them to pass an examination, such as for a license for mine foreman, for engineer, etc. They do not care whether they complete a course or not, provided they get the information they need in order to pass the examination. Quite a large number of students taking our courses in marine engineering never send in any work at all. They simply take their bound volumes, study from them, pass the examination, and get their license for one of the different grades of engineer. Several years ago the writer had considerable correspondence with the assistant foreman of the boiler department of the Richmond Locomotive Works. He was very enthusiastic regarding his work, and organized a class of about thirty-five persons employed in the boiler department, most of whom enrolled with us for our sheet-metal pattern drafting course. The superintendent and other officials of the company took great interest in his work, and furnished a room where the class could meet, and furnished desks, tables and other material, and encouraged the men generally in connection with their courses of study. The results, according to the assistant foreman, were extremely satisfactory. However, he did not furnish me with the names of any of the class until about two years after the correspondence was begun. I looked up the record of these students, and found that not a single one of them had ever sent in any work to us for correction. At the same time they were getting great benefit from their courses, and were entirely satisfied with them.

A careful examination of the records of a large number of students, for a number of years, indicates that about 60 per cent. of them send in one or more pieces of work. An examination of the records of our accounting department shows that about two thirds of the students pay in full for their courses. These facts force us to the conclusion that if a student does not pay, he does not study. There is no connection between the instruction department and the accounting department. Any student who sends in work on a paper will have his work corrected, and will have any questions answered that he may send us, regardless of whether he has paid for his course or whether he is a delinquent. At the same time, it is a fact that if a student does not pay, he does not study; while, if he does pay, as a rule, he does at least a certain amount of studying. Therefore, while our present total enrolment is a little over 900,000, it is not fair to count the actual number of students as being over about 60 per cent. of this, or about 540,000. From the figures and statistics prepared last month, we estimated that 533,000 students had sent in work on the examination questions of one or more instruction papers. From June 1, 1905, to May 31, 1906, the work on the examination questions of 517,849 instruction papers was corrected; 192,739 drawings were corrected; and 6,364 phonograph records, made by students in our language courses, were received and examined. The total number of pieces of work during this period, received from students, was, therefore, 716,952.

We compiled, about a year ago, a book giving the names, addresses and records of students who had completed about one third or more of their courses. There was excluded from this list those students taking a single subject, such as arithmetic, algebra, bookkeeping, etc., and also all the students in our school of electrotherapeutics—a total altogether of 40,261 names. The average enrolment during the period when the names were being taken off was 798,960. Hence, the number of students, living and dead, who might have been included in the book was 758,700. Taking 60 per cent. of these as active students, the number to be so counted is 455,220. The number of names included in the book is 75,774, which is about

16.6 per cent. of the number of active students. That is, 16.6 per cent. of the number of active students have completed one third or more of their courses, as shown by our records. The number of students who have entirely completed their courses, passed their final examination and been awarded a certificate or diploma is 12,143 (up to and including June 27, 1906), or about 2.6 per cent. of the total number of active students. Although this percentage may appear low, it should be borne in mind that it will greatly increase from now on. Instead of the schools being fifteen years old, they are really only about eight or nine years old, as measured by the bulk of the enrolments. A larger proportion of students are completing their courses now than at any time in the past. And in consequence of the exceedingly large enrolment at the present time, the number of graduates will increase very materially in the next few years.

Between February 7 and April 21 we issued over 600 diplomas, an average of 240 per month. The average for the same period next year will exceed this, and may average as high as 300 per month. In consequence of a falling off in the amount of work received during the hot weather, this average will not be maintained for the whole year; but it is safe to assume that between now and this time next year, at least 2,700 diplomas will be issued. This number will be increased during the following year. The percentage of increase in the number of students receiving diplomas will be far greater than in the number of new students enrolling. This conclusion is justified by the following fact: The book before referred to which contains the names and addresses of over 75,000 students is the second edition, and was compiled between May 16 and August 9, 1905. During this period the average enrolment was 798,960. The first edition of the book was compiled between January 18 and March 17, 1904, and the average enrolment during that period was 642,378. It was previously shown that 16.6 per cent. of the number of active students was included in the second edition of the book. I have no figures to show the exact number of names excluded corresponding to the 40,261 that were thrown out in making the previous estimate, but based on the number of students enrolled during the period that the first edition was being compiled, the number to be excluded would be 32,370. The number of names, therefore, considered in connection with the compilation of the first edition was 610,000. Hence, the number of active students at that time would be 60 per cent. of this, or 366,000. The number of names given in the first edition was 54,500, or 14.9 per cent. of the number of active students. In the short space of sixteen months the number of persons who had become eligible to have their names inserted in the book had increased 1.7 per cent. This is a remarkable showing, and we have every reason to expect that the number of students completing their courses will increase in the same or a greater proportion.

Some of the reasons why students do not complete their courses of study have been mentioned above. It may be of interest to consider other reasons why they fail to complete their courses. As a rule, if a student has only his own inclination to induce him to devote his spare time to obtaining an education, he feels the need of an education and knows the benefit it will be to him to possess it. At the same time, most persons do not possess sufficient grit and determination to persist in the line of work they have laid out for themselves, especially when they receive no special encouragement to do so. We do all we can to encourage the student, both by means of letters and by having our agents call on them. But there are many other influences that tend to discourage a student and to induce him to drop his course. Many students are obliged to stop studying on account of being forced to work very long hours and not having the time. Other students have an idea at the time they enrol that it will be a comparatively easy matter to study the course, and they become discouraged when they find they must work hard in order to understand the subject. Such students either do not begin to study, or else they cease studying almost as soon as they enrol.

A large proportion of our students are not only ignorant of the subject studied, but are also ignorant of *how* to study, that is, they have formed no habit of this kind, and it is necessary for us to teach them how to study, as well as the subject they do study. A large number have enrolled simply for the purpose of securing the text-books, as these are not for sale and can be obtained in no other way. Some enrol because their friends are enrolled. At the same time, when they receive their text-books and look them over, they become discouraged and never make any attempt to study. Some students may start in and work very well during the winter months and early spring, but during the summer months they stop for various reasons, perhaps temporarily; but later, when the weather has become cool again, they have laid aside their enthusiasm and do not resume, or, if they do, the attempt is spasmodic, and the studies are soon abandoned.

We have absolutely no way of compelling a student to study. We can not threaten him with suspension or expulsion. We have no inducement that we can offer him beyond prizes, and these do not seem to produce the desired effect; and the student himself frequently has direct encouragement to give up his studies, by reason of adverse criticism of his relatives and friends.

A considerable number of students may cease studying for a long time—several years in fact—and then begin again, and go on with their courses. Quite a number of students have objected to doing the work we require of them, saying they did not have the time, and stopped sending work on this account. We know of one student who finished all the work in our mechanical course (which we usually estimate will require about three years to complete), with the exception of one of the papers on machine design. This student did good work, and received very high marks. At the same time, he would not complete the subject of machine design, because, he said, he did not have time to make the drawings that we required in connection with these papers. His course was of great benefit to him, and when we heard from him last he was superintendent of a large power plant, and was receiving a very good salary. On account, however, of his not having conformed to our requirements, we were unable to give him a diploma, although he had actually completed the entire work of the course with the exception of this one paper. This is by no means an isolated case, but it is one that has occurred with considerable frequency. In some cases a student will not complete a course for the reason that it does not contain, in his opinion, as much on certain subjects as he thinks he should receive, and he does not care to study the course for the educational features only.

When we began to teach we did not know what the result of the experiment would be; and, furthermore, we did not have the demand for such a wide range of information on certain subjects as we have now. During the last three or four years we have been very busy in rewriting all of our older courses. These new courses will cover the subjects more completely than the older ones did, and there will be a larger number of subjects than were included in the former courses. Inasmuch as the new courses will meet the demands of our students better than the old ones did, we expect that there will be a great increase in the number of students finishing such courses, or, at any rate, in the number of students studying a part or all of the courses.

REPORT OF COMMITTEE ON NECROLOGY.

HOWARD SCOTT WEBB.

Howard Scott Webb was born in Hartland, Maine, October 10, 1865, and died at Hebron, Maine, June, 12, 1905.

Although ranked among the younger professors of the University of Maine, he had attained to an efficiency and weight of influence usually attaching to men older in years and in experience.

The main points in the story of Professor Webb's active life can be briefly given.

He fitted for college in the High School at Skowhegan, Maine, where his father held the position of Clerk of Courts. At the University of Maine he pursued the course in Mechanical Engineering, maintaining high standing in scholarship and graduating with the Bachelor's degree in 1887. Later he received the degree of Mechanical Engineer from his *Alma Mater*.

In the same institution he held the position of Instructor in Shopwork from 1887 to 1897, but devoted the year 1890–91 to graduate work at Cornell University. He served as Registrar of the University of Maine from 1889 to 1895 and as Secretary of the Faculty from 1890 to 1895. In 1897, Instructor Webb was granted leave of absence for two years, to prepare himself to take charge of the then recently introduced department of Electrical Engineering, a position for which he had shown an especial aptitude.

In further preparation for this appointment, he passed the year 1897–8 at the University of Wisconsin, where he was reported by Professor Jackson as the most brilliant student that had ever come under his instruction. From this institution he received the degree of Electrical Engineer. The following year, 1898–9, he devoted to practical work with the General Electric Company, at Schenectady, N. Y.

Thus equipped, he returned to the University of Maine in 1899, and served it with great fidelity and efficiency as Professor of Electrical Engineering for the remaining six years of his life.

As a teacher, Professor Webb was a man of rare ability. He had the power of imparting his own transparency of thought to others, and hence of securing to his pupils the mastery of even the most abstruse demonstrations. This lucid quality in his teaching won for him great acceptance with the students under his charge. He was modest, manly and upright, and inspired like qualities in those who came within the sphere of his influence.

While in the midst of active duties, early in the spring of 1905, he was attacked with pneumonia, which was followed by typhoid fever. In the subsequent prostration, tuberculosis developed, which, in his enfeebled condition, he was powerless to resist. Human aid and sympathy could not avert the sad and fatal result.

In his death, the University has met with a loss which is keenly felt and deemed well-nigh irreparable. His associates in the faculty have lost a companion and friend held in high esteem and affection, his classes, a faithful and wise counsellor and guide, and the larger community of which he was an estimable member, a man of the highest personal integrity and worth. By all, he will continue to be held in faithful and honored remembrance.

M. C. Fernald.

LYMAN HALL.

Dr. Hall was born in Americus, Georgia, February 18, 1859. His preparative school work was in the Americus public schools, after which he spent three years at Mercer University in Macon, Georgia, leaving college, however, before his senior year. The next two years were spent in office work at Americus. In 1877, he received an appointment to the Military Academy at West Point, from which institution he was graduated with distinction in the class of 1881. Immediately after graduation, however, young Hall received an honorable discharge from the army owing to an accident received on the parade ground during drill. Though this was the one great disappointment of his life—a disappointment from which he never fully recovered—these years at West Point had meant to him much. They had given him a mastery of the science of mathematics; but they had, more than this, fixed deeply in his character the ideas of thorough discipline, perfect truthfulness, and obligation to duty, which became prominent and distinctive elements of his personality.

Debarred from a career in the army, he entered the most obvious opening for a man of his tastes and acquirements; namely, the work of a teacher in a military school.

After two years as commandant at the old Georgia Military Institute at Kirkwood, Ga., he became, in 1883, Professor of Drawing and Assistant Professor of Mathematics at the South Carolina Military Academy in Charleston, S. C. He filled this position until 1886, when he returned to the Georgia Military Institute as Commandant and Professor of Mathematics.

During his residence in Charleston, he married Miss Annie Toomer Jennings, who with four children, two daughters and two sons, survive him.

In October, 1888, the Georgia School of Technology formally opened its doors, and Dr. Hall began his connection with the school in the capacity of Professor of Mathematics. During the busy years that followed, through his wide and exact knowledge, his genius for teaching, his enthusiasm in his work, and his force of personality, he became the dominant figure in the school. He found time, moreover, to write and publish several mathematical treatises—the best known of which, his "Elements of Algebra," has been and is largely used in high school work; to take an active interest in the local military companies; and to extend his acquaintance with men of state and men of affairs. In this last respect, Dr. Hall distinguished himself from the great body of school men. He never confined his horizon to the four walls of the school room or the office. His eye was continually on the world and its progress, and few men in the South in like positions have had so intimate an acquaintance with the great world of practical affairs. A large part of the effectiveness of his management of the school may be traced direct to this cause.

During the school year 1895–1896, the president of the Technological School resigned his office, and, after successfully filling the unexpired term, Dr. Hall was unanimously chosen president in June, 1896. He now began at once carefully to lay plans for the development of the institution, to enlarge the plant, to extend its influence, to raise the standard and value of its work, and generally to increase its usefulness; and threw himself—all of himself—into the work with a generous ardor and devotion that made failure impossible. Every detail of the school system was brought under the scrutiny of his office; the state legislature was untiringly besought to increase its annual appropriation; when the state was unwilling or unable to supply the needed funds, application—undiscouraged by refusal—was made to philanthropists and monied men. Through his own solicitation, Dr. Hall secured for the school fully $100,000. Under this masterly management, the school grew, grew by leaps and bounds, and with it grew the name and fame of Lyman Hall, until he became known as one of the leading educators of the United States; he was not infrequently invited to speak before even the great institutions of the East. In recognition of his work, Washington and Lee University conferred upon him in 1903 the degree of LL.D.

A strain of this kind, however, could not last indefinitely, and the collapse came just as he was realizing the fruition of his labors. His health failed completely during the spring of 1905, and on the sixteenth of August he died in a sanatarium at Dansville, N. Y. His body was brought for burial to Atlanta, where it lies in the beautiful West View Cemetery.

The best record of Dr. Hall's life, however, is written in the history of the school to which he devoted his best energies; and what therein he attained can be realized only by comparing the crude beginnings of his work with the present fulfilment of his ideal.

In 1888 the Georgia School of Technology was definitely established, and opened to the boys of Georgia and the South. A technical school was a novelty in the state. It excited curiosity, and the immediate patronage was highly gratifying. Then the novelty began to wear off, and the school entered upon a period of decline. The average attendance dropped to about sixty. Even the ardent champions of the institution feared that it was doomed to failure. The legislature was indifferent to it, and was reluctant to provide for it out of the state funds. Its equipment, moreover, was inadequate in every particular. This was the condition of affairs when Dr. Hall became president. Then came a change. At every turn he began the work of rehabilitation and expansion. Year by year, larger state appropriations were pled for and finally secured; new buildings appeared; the present beautiful campus was evolved from the former dreary surroundings; new departments and courses were added; the corps of instructors was increased; more students were enrolled: and the school gradually took an unquestioned rank among the really excellent polytechnic institutions of the United States. To-day nine handsome brick structures, equipped with every modern appliance for technical education, have supplanted the two buildings that faced the campus in 1895; the attendance has become about six hundred; more than forty instructors teach these young men; and degrees are given in six branches of engineering.

It is in figures of this kind that it is easiest to show what the life of Lyman Hall has meant to Georgia, but the best part of his work lies behind and beyond mere statistics. Dr. Hall was the real creator of technical education in his state. It was he who taught the public the essential difference between technical training and technical education; he drew the definite line of demarcation between the artisan and the engineer. Dr. Hall taught the people of Georgia the dignity of the overalls.

The death of Lyman Hall was a severe loss to the institution over which he presided, but the solidity and soundness of his work was such that even his death could not retard its continued growth and expansion; and the Georgia School of Technology to-day looks forward confidently to a future of ever-increasing dignity and usefulness—the one great memorial to the man who, without any savor of exaggeration, fashioned it out of his own splendid life.

William Gilmer Perry.

ALBERT HENRY HELLER.

Albert Henry Heller, youngest son of Mr. and Mrs. George C. Heller, was born at Wapakoneta, O., December 18, 1866, attended the common schools, and graduated from the High School of that place. He entered the service of a local drug firm, where he served for some time, and might have remained in that business had he not been persuaded to attend college by teachers who had earlier noticed his mental aptness.

He entered the Ohio State University in 1885 and graduated with the degree of civil engineer in 1890. During his college course he spent one year in teaching school to gain funds with which to finish the fourth year. After graduation, he entered the service of the Massillon Bridge Co. as draftsman, and his subsequent rise in his chosen line was steady. Draftsman, Massillon Bridge Co., 1890–91; draftsman, Mt. Vernon Bridge Co., 1892; assistant chief engineer Youngstown Bridge Co., 1893–99; chief engineer of the same company, 1899–1900; he became assistant to the vice-president of the American Bridge Company upon the absorption of the Youngstown plant by the larger company. While connected with this latter company he served in various responsible capacities in New York, Pittsburg and Atlanta.

Professor Heller resigned from the service of the American Bridge Co. in the latter part of 1901, and was looking for a suitable place to locate a cement factory when he accepted the call to his *Alma Mater* as Professor of Structural Engineering in April, 1902. He brought to his work at the university unusual qualifications. Deeply interested in the theory of his subject, he was eminently qualified from the practical standpoint to teach structural engineering. He had served in each capacity from subordinate to chief, and not less valuable was his experience in the executive offices of the larger company, where the amount of business transacted forced one to a quick appreciation of method and essentials.

Among his professional brethren, Professor Heller gained no wide acquaintance. He devoted himself exclusively to his work and was seldom seen at social functions. Never of robust health, and naturally of a studious and retiring disposition, his declining strength forced him still further into seclusion. By some fatal chance his earlier physicians failed to diagnose his trouble. He was treated for a year or more for a supposed case of intestinal indigestion, visiting Colorado during the summer of 1905 in hopes of receiving some benefit, but getting none.

He carried on his class-work until long after he should have given up all effort. When his fatal malady was diagnosed as advanced bronchial tuberculosis, the news came to him as a complete surprise, and with grief he laid down his unfinished labors. Upon confirmation of the diagnosis he saw clearly his hopeless condition and wished to die quickly. He passed away on February 20, 1906, only thirty-two days after he had given up his college classes.

In Professor Heller's death the engineering and teaching professions sustained a distinct loss. He was esteemed alike by those who served over or under him, in college and out. He was painstaking and thorough himself and he expected no less from his students. This did not make him popular with any who might be inclined to shirk, but it won for him the high esteem of those whose opinion was worth having. If college students are better qualified as alumni to judge the value of their training, then the worth of Professor Heller as an instructor is attested by the pleasure with which his former students called on him when they came to the city. His interest in their welfare was undoubted.

In addition to his college work he contributed a few articles to the technical journals, and at the time of his death was writing a treatise on structures. The first portion of this, entitled "Stresses in Structures and the Accompanying Deformations," although not yet formally published, was printed and is in use as a text-book. Professor Heller also acted in the capacity of consulting engineer to a number of corporations.

He was a man of convictions and looked with serene confidence to a better future world. Throughout his life he had been a consistent Christian, and he faced forward with the steady gaze of a clear faith. His body was taken for burial to his native town. Services were from the Central Lutheran Church, of which he had been a member since early youth.

O. E. SHERMAN.

GEORGE WASHINGTON ATHERTON.

George W. Atherton, LL.D., President of The Pennsylvania State College, died on July 24, 1906, at his home in State College, Pa., in his seventieth year.

In his death the cause of education suffered an inestimable loss. Especially in the development of that new departure in education, provided for by the establishment of the land-grant institutions, his magnificent abilities and indefatigable devotion were of distinguished service. Keen intellect, unbending will, wisdom, tact and discretion, untiring devotion to duty, high ideals of honor, largeness of heart and charity, winning and gracious personality at once dignified and persuasive—qualities eminently distinctive of Dr. Atherton, the scholar, the man, the gentleman—combined to give him a rare power and strength in the organization of enterprises and in the control of men and affairs.

George Washington Atherton was born on June 20, 1837, at Boxford, Mass. At twelve years of age, upon the death of his father, he became self-supporting and assisted in caring for his mother and two sisters, at first by working in a cotton mill and later by farm work and teaching. By his unaided efforts, he made his way through Philips Exeter Academy, and in 1860 entered Yale University in the sophomore class.

After his graduation in 1863, he responded to the call to arms and served throughout the Civil War with undaunted courage and efficiency. Before his discharge on account of illness he had achieved an honorable record and was promoted to a captaincy. His marriage to Frances D. W. Washburn had occurred in December of 1863. After leaving the army, be became instructor in the Albany Boys' Academy. From this position he was called to a professorship in St. John's College, Annapolis, Md.

In 1868, he accepted a chair in the Illinois Industrial University (now the University of Illinois) and here first became interested in that practical type of education which was destined to so immediate and rapid a growth in importance in this country. During his connection with this institution, Dr. Atherton's relations with its first president and organizer, Dr. Gregory, were of the most happy nature and became firmly established in a life-long friendship. In the following year he was called to the chair of political economy, then newly established, at Rutger's College, New Jersey. He retained this position throughout the fourteen years which passed before his election to the presidency of the Pennsylvania State College. During this period he studied law and was admitted to the New Jersey bar, and at the same time manifested an active and serviceable interest in all public affairs. In 1873, he was a member of the Board of Visitors to the U. S. Naval Academy. In 1875, he was appointed by President Grant on the commission to investigate the charges of corruption at the Red Cloud Indian Agency. In 1878, was chairman of a commission of revision of the state system of taxation. In 1873, as the result of much thought upon the subject of higher education for the industrial classes with special reference to the provisions of the Morrill Act of 1862, he prepared an exhaustive paper under the title "The Relation of the General Government to Education," and presented it before the National Educational Association.

In 1882, after what would seem to have been a life of preparation of peculiar fitness, Dr. Atherton became president of Pennsylvania's Land Grant College. The people of the state, lacking appreciation of the significance to them of an institution of this character, were at this time either indifferent or unfriendly in their attitude toward it, and its condition was one of disorganization and neglect.

All of Dr. Atherton's well-known fund of courage and strength of purpose were required to enable him to face this new problem with the enthusiasm and never-failing optimism necessary to its successful solution. He was an indefatigable and tireless worker, continually spending himself to the point of physical exhaustion, wherever his interests were enlisted. His colossal labors in the service of The Pennsylvania State College were early rewarded by a change in public sentiment toward the institution, and by an almost phenomenal expansion in every direction during the twenty-four years of his administration. Seemingly unsurmountable difficulties were met and overcome with indomitable courage and energy, and The Pennsylvania State College came to be ranked with similar technical institutions of earlier and more favored development.

Throughout this period he did not fail to respond to the calls of public duty, and in 1887 accepted an appointment to the chairmanship of a commission to inquire into the practicability of introducing manual training into the public school system. His comprehensive report upon this subject is regarded as authoritative in both Europe and America.

By those who were associated with him for many years in national legislation relating to the land-grant colleges, the name of Dr. George W. Atherton is recognized as pre-eminent among the inspired pioneers who so generously devoted themselves to the development of the "liberal and practical education for the industrial classes" which has effected so fruitful a revolution in the educational methods of the age.

LOUIS E. REBER.

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